THE ROLE OF GUARANTEED INCOME IN HEALTHY AGING: CANADIAN PUBLIC PENSIONS AND THEIR ASSOCIATION WITH OBJECTIVE HEALTH MEASURES

by

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ABSTRACT

Background: Old Age Security (OAS) represents an intervention through which income-related inequalities in health may be improved. The goal of this cross-sectional study was to investigate the objective health status (allostatic load) of older adults in Canada by level of financial security and OAS receipt.

Methods: Using data from the Canadian Longitudinal Study on Aging (CLSA) (n=15,691), ordered logistic regression was used to measure associations between individual income-related variables (income, savings, homeownership, a composite "financial security" variable) and allostatic load. The relationship between allostatic load and receiving OAS by level of financial security was assessed on average and across deciles of allostatic load.

Results: Financially insecure older adults were significantly more likely to have higher (worse) allostatic load compared to the financially secure (OR_{Male}: 1.512, 95% CI: 1.279, 1.787; OR_{Female}: 1.471, 95% CI: 1.287, 1.681). Financially insecure older adults receiving OAS as highest personal income source were significantly more likely to have a lower (better) allostatic load compared to other financially insecure older adults (OR_{M}: 0.398, 95% CI: 0.227, 0.696; OR_{F}: 0.677, 95% CI: 0.483, 0.949). Additionally, the highest allostatic load deciles among the financially insecure were lower in those receiving OAS.

Discussion: While longitudinal data is required to study potential causal effects, these results imply OAS may play a role improving health outcomes and narrowing income-related health inequalities. These findings may have implications for older adults, other vulnerable populations, and future directions of Canadian public policy.

LIST OF ABBREVIATIONS USED

MBM	Market Basket Measure
LICO	Low-Income Cut-Off
GAI	Guaranteed Annual Income
MINCOME	Manitoba Minimum Income Experiment
OAS	Old Age Security
GIS	Guaranteed Income Supplement
CPP/QPP	Canada Pension Plan/ Quebec Pension Plan
CLSA	Canadian Longitudinal Study on Aging
DCS	Data Collection Site
HDL	High-Density Lipoprotein
HbA1c	Glycated Hemoglobin
WHR	Waist-to-Hip Ratio
BMI	Body Mass Index
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
CRP	C-Reactive Protein
UQR	Unconditional Quantile Regression

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CHAPTER 1: INTRODUCTION

Universally, health tends to be better among the wealthy and worse among the poor.[1] Low income and financial insecurity have been consistently associated with increased morbidity and mortality around the world, including in Canada. It should come as little surprise therefore that when Canadians turn 65, high-income men and women can expect to live 4.7 years and 2.8 years longer than their low-income counterparts.[2] Despite reductions over recent years, poverty rates and low income remain a concern in Canada given the implications they can have on health systems, health spending, and overall population health.

One policy solution that has become increasingly popular as a poverty-reduction strategy is a guaranteed annual income (GAI). A GAI consists of a government-supplied minimum income provided to all citizens with very little eligibility criteria. While formal GAI does not exist in Canada today, Old Age Security (OAS) is an analogous program. OAS is a federally delivered pension provided monthly to almost all Canadians from the age of 65 onwards. It has previously been shown to improve self-rated health outcomes in some of the most poor and vulnerable Canadians.[3] But OAS is an expensive program, and increases in life expectancy (among other reasons) have seen it become a considerable expense for the Canadian federal government in recent years. Increased research on the health benefits of OAS are therefore necessary to inform the future direction of this policy and other potential GAI programs in Canada.

This cross-sectional study aimed to investigate the objective health status of those receiving OAS with different levels of income security. Biomarker and financial data were taken from the Canadian Longitudinal Study on Aging (CLSA) to develop allostatic load, a measure of biological wear-and-tear, and assess how it differs in financially insecure older adults who receive Old Age Security.

CHAPTER 2: BACKGROUND

2.1. Financial Resources and Health Research

The relationship between socioeconomic factors and health is well documented[2,4–7] through the wider literature covering the social determinants of health. Income and income-related gradients in health have been studied across the world, including Canada, where despite a publicly funded healthcare system, health disparities continue to widen.[5,8] As a result, poverty and income inequality remain persistent public health issues in Canada today, with implications for individual health, population health and healthcare spending.

2.1.1. Low Income and Health

Low income has been consistently associated with increased mortality, morbidity, and poor health behaviours. At age 65, high-income Canadian men and women can expect to live 4.7 years and 2.8 years longer than their low-income counterparts.[2] Health-adjusted life expectancy, a measure of years of good health one can expect to have, is greater for high-income groups across both sexes.[2] Canada's lowest earning men and women have been shown to have 2.79 (95% CI: 2.66, 2.91) and 2.50 (95% CI: 2.36, 2.65) times the risk of premature mortality, despite absolute decreases in premature mortality rates over the past 30 years.[6] Income-related mortality gradients have also been observed within the health care system. In general practitioner settings in Toronto, Ontario, patients with annual incomes exceeding $80,000 have been shown to have a mortality rate ratio of 0.34 relative to those with annual incomes below $20,000 (95% CI: 0.12, 0.97).[9] Low income is also the strongest predictor of severe food insecurity,[10] which has been associated with 2.60 times greater odds of mortality in Canadians compared with those who are food secure (95% CI: 2.17, 3.12).[11]

Around the world, the implications of low income are similar. In the United States, life expectancies between individuals who fall into the top 1% and bottom 1% of the income distribution have been shown to differ by 14.6 years for men (95% CI: 14.4, 14.8), and 10.1 years for women (95% CI: 9.9, 10.3).[12] In the United Kingdom, mortality rates for

low-income individuals (4.93/1000PY, 95% CI: 4.00, 6.06) are significantly higher than those for high-income individuals (2.99/1000PY, 95% CI: 2.48, 3.60).[4] Increasing income has been shown to increase life expectancy, but given dollar increases are more impactful on health for those at lower incomes. For example, an increase in income from $14k to $20k (15th vs 20th income percentile), has been associated with the same life expectancy increase (0.7-0.9 years) as an increase from $161k to $224k (90th vs 95th income percentile) in the United States.[12] In other words, $6,000 at the low end of the income distribution is equivalent to $63,000 at the high end. As income increases, it has a diminishing return on life expectancy.

In terms of morbidity and health behaviours, low-income Canadians have been shown to have twice the rates of diabetes, poor self-rated mental health, and mental illness hospitalization rates compared with high-income Canadians.[13] Low income has been associated with 1.6 times the odds of higher allostatic load and general life stress (95% CI: 1.2, 2.0) in the United States[14] and Canada,[15] and obesity has been shown to be more prevalent in low-income households than high-income households.[13] Elsewhere in the world, low income has been associated with more functional limitations,[16] mental disorders,[17] and higher risk of osteoarthritis,[18] among other conditions. Low-income Canadians are less likely to consume fruit and vegetables, obtain adequate sleep, engage in physical activity, and are more likely to be a current smoker.[19,20] As a result, low-income Canadians are more likely to be obese and become a high-cost healthcare user,[20] with significantly higher rates of hospitalizations directly attributable to alcohol use despite consuming less alcohol in general than higher-income groups.[4,21] A large international report on modifiable health risk factors found that 70% of cardiovascular disease cases and deaths worldwide can be attributed to behavioural risk factors that are consistently associated with low income and financial insecurity.[22]

2.1.2. Financial Assets and Health

Evidence suggests that non-monetary assets and wealth may also be important measures of socioeconomic status, particularly where income and wealth are decoupled from each other.[23] One instance where this discrepancy could occur is if someone is wealthy, but currently unemployed. Another group that is prone to this low-income high-wealth

paradox is older adults, as income has been shown to decrease around retirement and become less relevant in terms of consumption and overall stability.[23–25] Assets and wealth, therefore, help provide a more complete understanding of one's financial situation compared to income alone. As a result, they are important considerations when discussing health and health outcomes.

Non-liquid financial assets, such as homeownership, have been associated with various health measures in Canada[26–29] and around the world. Homeownership has been associated with a 69.40% increase in the likelihood of reporting good or better health the province of Alberta,[27] while food insecurity rates have been shown to be as high as 17.3% in non-homeowners (in contrast to 3.3% in homeowners).[26] In the United States, non-homeowners have been shown to have significantly higher odds of having a major depressive disorder,[30] and those behind on their mortgage payments are more likely to report fair/poor health or a recent anxiety attack.[31] In the United Kingdom, homeownership has been associated with higher self-rated health,[32,33] while renting has been associated with significantly elevated levels of C-Reactive Protein,[34] and higher allostatic load.[35] Finally, in Finland the hazard ratio for all-cause mortality in renters has been shown to be 2.06 in males (95% CI: 1.98, 2.14) and 1.73 in females (95% CI: 1.65, 1.81), with excess mortality for nearly all causes of death being seen among individuals who rent.[36] While there may be policy differences worth consideration when discussing these between-country comparisons, owning a substantial asset such as a home is universally representative of at least some cumulative wealth[36] and overall financial stability, both of which act to provide a cushion against the possibility of financial shock.

Liquid assets in the form of savings and investments represent a more active buffer against the potentially health damaging impact of lasting income fluctuations.[24,37] Such liquid assets may be referred to as wealth,[23] net worth,[37] or savings[30]; all aim to capture the same concept of a non-income measure of wealth. A consistent relationship has been shown between greater wealth and decreased mortality, increased functional status, and fewer chronic diseases.[37] Conversely, lower savings have been associated with increased odds of having a major depressive disorder,[30] and poor self-rated health.[37–39] One study showed participants categorised in the lowest net worth quantile had 4.98 times the

likelihood of reporting fair or poor health (95% CI: 3.42, 7.24), and 2.85 times the likelihood of being a current smoker (95% CI: 2.02, 4.03) compared to those of the highest income quantile.[39] Similar to housing, higher amounts of wealth/savings provide a level of security against income fluctuations.[23,24] It is clear therefore that measures of wealth and assets are important considerations when discussing the relationship between financial security and health, particularly in older adults.[37]

2.1.3. Income Inequality and Health

It has also been suggested that more than absolute measures of income and wealth may be relevant for comparative health outcomes. The relative income hypothesis suggests health is also associated with the perceived rank of one's income compared to others.[40] Self-assessed income rank has at times been shown to be a stronger and more consistent predictor of health than absolute income amount,[4] so the distribution of income across a population i.e., income inequality, may be relevant to the income and health relationship as well. People in areas with a greater income inequality, as measured through the Gini coefficient, tend to have shorter life expectancies and higher adult mortality.[41] For example, living in a US state with higher Gini coefficient (indicative of greater income inequality) has been associated with an increased risk ratio for all-cause mortality (1.12, 95% CI: 1.04, 1.19),[42] and increased odds of reporting fair or poor health (1.25, 95% CI: 1.17, 1.34).[43] At both the state and country level, greater income inequality has also been associated with depressive symptoms and negative health behaviours,[40] along with a decreased likelihood of having a regular physician or place of care in Canada.[8] The culmination of this literature is the determination that higher levels of income inequality and social class-related divisions may cause worse average population health,[44] though reverse causality between health and income inequality has also been suggested.[45] What remains apparent however is the general financial resources one has, along with the distribution of those resources within a population, are both relevant to the overall health of populations.

2.2. Low-Income in Canada

In Canada, low-income is quantified by having an annual income below the Market Basket Measure (MBM). The MBM is Canada's official poverty line and represents the

cost of a specific basket of goods and services consistent with a modest standard of living in a particular geographic area.[46] The most recent data available as of June 2022 indicates the lowest Canadian MBM for an individual is in rural regions of Quebec ($19,311), and the highest MBM is in Vancouver, British Columbia ($25,285).[47] In Halifax, Nova Scotia, the average MBM for a single individual is $23,264.[47] Statistics Canada formerly used low-income cut-offs (LICOs) as the poverty line for individuals, which ranged from $18,192 in rural areas to $26,426 in dense urban centres.[48] Poverty rates according to the MBM have been on the decline in Canada over the past several years. In 2020, 7.7% of Nova Scotians lived in poverty according to the MBM, including 4.5% of those over 65,[49] comparable to the national averages (6.4% and 3.1%),[50] and markedly reduced from 2019. Individuals living under the MBM represent some of the most vulnerable Canadians in terms of financial insecurity and associated poor health. As Canadian socioeconomic gradients in health continue to widen,[5,16] solutions focused on raising up the poorest Canadians may represent a viable path towards improving both individual and population health outcomes. One straightforward policy through which income can be increased for the worst-off is a guaranteed annual income.

2.3. Guaranteed Annual Income: An Income Intervention

A guaranteed annual income (GAI) represents a possible way to mitigate the health consequences of financial insecurity-related health inequalities and inequities. Going by many names, including universal basic income, GAI is a form of government-supplied minimum income provided for all citizens with very little eligibility criteria.[51] It is a modest, reoccurring payment provided on a consistent basis to all such that financial stability is provided while not disincentivizing labour market participation.[51] The appeal of GAI is that it has the potential to address problems that are currently the result of inadequate income or inadequate coverage by existing services, such as food insecurity,[52] unmet healthcare needs,[53,54] homelessness or eviction,[55,56] and preventable mortality.[12,57] Improvements in these areas would mean improved social conditions for some of the worst off,[58] addressing both their immediate needs while potentially mitigating the effects of broader, population-level health inequities.

The seminal 1985 work of Rose,[59] and much follow-up research since, provides a useful framework to discuss GAI in the context of health interventions and the resulting health distributions. Public health interventions are widely discussed and are often thought to have two possible goals: to improve overall population health or to reduce health inequalities.[60] Both have their strengths and weaknesses. For example, universal policies may produce overall health gains in a population (i.e., improvements in average health), but larger gains for the better-off may mask smaller progress made by the worse-off and inadvertently increase health inequalities.[61] Conversely, targeted programs focused on the most vulnerable may produce improvements in the health of those groups (i.e., narrow the distribution) but risk stigmatization, high-costs, and minimal aggregate health improvement for the overall population.[61]

An idealized GAI program is a universal intervention, providing a level of support to all citizens without means-testing or otherwise. Such a program, therefore, may hold the potential to inadvertently increase health inequalities as outlined above. Rose would consider GAI a radical population intervention,[59] having its impact on the fundamental causes of poverty and the context in which it evolves, contrary to the acute impact a temporary intervention would have, such as a one-time payment. By design, radical interventions require less agency from beneficiaries, as the intervention acts to address structural causes of health inequalities (i.e., in the case of GAI, income inequality) as opposed to encouraging a behaviour change, for example.[62] Because they rely less on individual agency and aptitude, which can vary between socioeconomic groups, radical population strategies may have a more equitable impact and therefore may not necessarily increase health inequalities.[62]

Furthermore, the various health policy typologies developed by Graham[63] and expanded on further by Benach[60] have shown how improvements to population health and reductions in health inequality need not be mutually exclusive. Graham contends that policies focused on reducing health inequalities in fact benefit from a population-wide approach, as income-related health gradients are seen across the whole population. Improvements are therefore necessary across the whole socioeconomic distribution, but at a faster rate of for those worse-off.[63] This approach is further developed by Benach's

'Redistributive Policies,' which describe universal policies that are applied specifically on the causes of poor health and overall social disadvantage (for example, income).[60] The well-off would not be expected to benefit much from such a policy, but health benefits would be seen to increase in magnitude and impact down the social gradient. The result therefore could be both a reduction in the health gap between groups (i.e., a narrowing the distribution), and an improvement in the population average.[60]

Different policies serve different purposes. The choice of policy depends on the nature of the health problem,[60] though gaps do exist between policy need and policy design. As a result, GAI as a universal and primarily economic intervention could foreseeably have a range of implications on individual health and population health, both in terms of its mean and distribution.

2.3.1. Guaranteed Annual Income Policy and Experiments

GAI is not a new concept within Canadian political discussions and policy. First proposed in Alberta at the height of the Great Depression, it was shut down by the Federal Government at the time due to insufficient funds.[64] In 1968, when the Fifth Annual Review from the Economic Council of Canada reported the top fifth of income-earners had more than 10 times the income of the bottom fifth, the concept was raised once more as a poverty reduction strategy.[65] This led to the inception of the Guaranteed Income Supplement,[64] providing further support for particularly low-income individuals, but no widespread GAI was adopted. Discussions around GAI have since continued at the federal level, including by then Prime Minister Jean Chrétien[65], former conservative Senator Hugh Segal,[64] and most recently, New Democratic Party MP Leah Gazan. Bill M-46 proposed a guaranteed livable basic income to replace the COVID-19 pandemic-related Canadian Emergency Support Benefit in a "concerted effort to eradicate poverty and ensure the respect, dignity and security of all persons,"[66] but was defeated on the floor of the House of Commons in April 2021. Despite no legislative success, continued discourse means the Canadian public is likely at least familiar with the idea of GAI.[64]

GAI has been piloted in Canada before. In the mid 1970's, GAI was a reality for many residents of Manitoba, and all residents of the town of Dauphin. The Manitoba Basic

Annual Income Experiment (MINCOME) was a federally and provincially backed initiative to investigate the effects of a GAI on Manitoban families.[65] MINCOME included Dauphin as a saturation site, whereby every resident of the town was eligible for GAI with no conditions.[67] The maximum available amount was $19,500, equal to 49% of median household income in 1976, and reduced as individuals earned more through employment.[68] Over the study period, hospitalizations in Dauphin fell by a statistically significant 8.5% relative to controls.[69] These reductions were largely attributed to 'accidents and injuries' and 'mental health diagnoses,' both of which are consistently associated with lower socioeconomic status.[69] Additionally, weaker evidence provided support for higher rates of high school completion and lower rates of pregnancy in younger women.[67] Labour market participation in Dauphin was moderately reduced by 11.3 percentage points[68] and by less in other parts of Manitoba.[67] These decreases were mostly within individuals more likely to be elderly or unwell, or younger in age and considering education, training, or engaged in care-work activities.[68] Training or care-work are both socially productive and likely improve collective wellbeing, but are often not reflected by conventional income and employment statistics.[68] Changing political environments and rapid inflation meant MINCOME ended suddenly in 1978.[70]

The Ontario Basic Income Pilot represents another experiment with GAI which was cancelled before its full potential was realised. The pilot had enrolled more than 4000 low-income people to receive significantly higher payments than existing social assistance programs and, like MINCOME, allowed individuals to work while receiving benefits.[71] Despite its premature cancellation in 2019 after less than two years, participants still reported experiencing greater housing stability, nutrition, improvements in social relations, and decreased stress while the program was running.[71]

Evidence from elsewhere in North America adds to these observations. The Eastern Band of Cherokee Indians Casino Dividend was a modest GAI provided to tribal members from the profits of a local casino, reaching $6000 annually in 2001.[72] After the program began in 1996, poverty decreased more than 30 percent,[72] mental health outcomes improved,[72] educational attainment increased,[73] and criminal behaviour reduced.[73] Self-reported life span, a socioeconomically associated assessment of a relatively short future

lifespan, also increased significantly within recipients of the dividend.[74] Another such program, the Alaska Permanent Fund, provides Alaskan residents with around $2000 annually.[75] Despite its modest size, the fund was shown to decrease poverty by 2.3% over five years, and evidence suggests around 25% more people would have fallen below the poverty line had the fund not existed.[76] The program was also shown to have no effect on employment rates.[75]

2.3.2. Canadian Public Pensions: Old Age Security

An analogous program to GAI exists in Canada today through the federally delivered Old Age Security (OAS) public pension, which guarantees an income floor to Canadians upon reaching age 65. A universal pension since 1952, it was signed into law as an act to provide for the security of older adults and prevent poverty in retirement. Enrollment for OAS is automatic in most cases but can be deferred up to five years, and all residents are eligible if they have lived in Canada for 10 years since turning 18. In 2022, the maximum monthly payment amount for OAS is $648.67, and additional income can be earned while collecting OAS.[77] For those with exceptionally low income, the Guaranteed Income Supplement (GIS), a subsidiary OAS benefit, provides additional guaranteed payments of up to $968.86 per month. This means that OAS sets the annual income floor for anyone over 65 at $19,410.36 as of June 2022.[77] The most obvious difference between OAS and a GAI is that OAS is available only for individuals over the age of 65, or younger in some special cases such as being widowed to an OAS recipient. OAS represents a considerable income increase compared with every province's social assistance program, for reference Nova Scotia's income assistance for an unattached single person as of 2022 is at most $8,232 per year.[78] At least 80% of low-income Canadians over 65 report OAS as their main source of income.[79]

Given the relationship between income and health, it is unsurprising that previous research has demonstrated significant health benefits from receiving OAS in Canada. For low-income Canadians, becoming eligible for OAS has been associated with reductions in food insecurity[79,80] and improvements in self-reported physical health, self-reported mental health, and self-reported functional health outcomes.[3] Those aged 60-64 report almost twice the prevalence of food insecurity (27%) as those aged 65-69 (14%),[79] while

those aged 55-64 reported twice the rates of poor/fair mental health (18%-24%) as those aged 65-74 (8%-10%).[3] All self-rated health and health-related measures mentioned appear to significantly improve in low-income Canadians when OAS is received after turning 65.[3]

Along with Old Age Security, the Canadian public pension system also includes the Canadian Pension Plan/Quebec Pension Plan (CPP/QPP).[81] While OAS is non-contributary, federally funded and automatic, CPP/QPP is a contributary pension, meaning eligibility criteria involves having made contributions to the pension across one's employed life. Individuals enrolled in CPP/QPP can begin receiving benefits with a reduction after turning 60 or wait until 70 to maximise payment amounts. Both contributions and payment amounts are based on earnings, and individuals can continue to work while receiving CPP/QPP. Thus, a combination of employment income (where applicable) and CPP/QPP income is used to determine OAS payment amounts upon turning 65, which begin to be clawed back if income exceeds $79,054 and stop altogether above $133,527.[77] As a result, OAS is oriented more towards poverty-reduction and therefore tends to be relied upon more heavily by those with lower pension payments and income.

Although mandatory retirement was officially prohibited in Canada by 2012,[82] the age of eligibility for Old Age Security effectively sets a minimum retirement age for individuals who lack the CPP/QPP pension, or other financial means, to retire earlier. OAS, upon its inception in 1952, was originally only provided to Canadians older than 70. In 1965, the age of eligibility was reduced to 65.[83,84] Advocates for raising the age of eligibility for OAS receipt cite fiscal and labour market constraints, suggesting that significant increases in longevity over the past half-century have rendered the program unsustainable.[85,86] However, given the health improvements with which OAS has been previously associated in low-income older adults,[3] blanket changes to OAS may not be the best option. Raising the age of eligibility, for example, does not consider the importance of OAS for financially insecure older adults, the demographic with the most to lose should the age of eligibility be raised. For these older adults, qualifying for OAS and the new, guaranteed income stream that will persist for the rest of their lives is a

major life event. This dramatic shift in income amount and security could predicate important and lasting health improvements, improvements which would be denied if the age of eligibility for OAS was raised.

2.4. The Financial Security-Health Pathway

The pathways that link financial security and health are widely theorized. They can be relatively direct (for example, lead exposure in substandard housing leading to cognitive impairments in exposed children), or more prolonged (for example, increased access to cigarettes, concentrated fast-food in poorer neighborhoods leading to poorer nutrition over time).[87] Low income and financial insecurity are less tangible; they are multi-faceted stressors which appear to influence human physiological systems over time. One proposed measurement of the biological toll these environmental stressors can have on individual health is allostatic load.

2.4.1. Allostatic Load

Allostatic load refers to the physiological dysregulation, or wear-and-tear, on the body in response to environmental demands.[88] With repeated or chronic exposure to stressors, such as low income or financial insecurity, physiological systems may shift out of their normal operating range, resulting in dysfunction that can predispose an individual to poor health.[15] Allostatic load as a health measure attempts to measure this dysfunction through the use of biomarkers from several major physiological systems, including metabolic, cardiac, and inflammatory indicators, all of which are typically associated with general concepts of ongoing, chronic stress.

Allostatic load was first introduced by McEwan and Stellar in 1993.[88] Since then, numerous studies have attempted to quantify allostatic load with a variety of biological variables. Early indices included stress hormone measurements such as cortisol and epinephrine,[89–91] regarded as primary mediators of allostatic load.[92,93] These biomarkers, however, are strongly affected by the acute context of the measurement due to their frequent fluctuation.[94] When acute changes continue over time, biological systems compensate for the over or under production of primary mediators leading to more chronic secondary outcomes.[92,93] Statistics Canada suggests an allostatic load index using

nine variables considered secondary outcomes: total cholesterol, high density lipoprotein, glycated hemoglobin, waist-to-hip ratio, systolic blood pressure, diastolic blood pressure, resting heart rate, c-reactive protein, and albumin.[15] Recent literature is more consistent with the use of these variables in allostatic load indices as they are more reflective of chronic stress and the associated poor health outcomes that occur over time.[7,95,96] Despite some variation, the concept allostatic load tries to assess – physiological wear and tear due to chronic stress – has remained consistent. It is more than just a measurement of the changes within each variable it contains; allostatic load reflects the cumulative health toll of life experiences involving ordinary events, major challenges or stressors, and the physiological consequences of health-damaging behaviours.[97]

2.4.2. Determinants of Allostatic Load

Allostatic load is the result of a complex web of lifestyle, socioeconomic, and demographic factors. Lifestyle factors, such as poor sleep quality, unhealthy diet, alcohol consumption and poor smoking habits have all been associated with higher allostatic load scores, while physical activity is associated with reductions in allostatic load.[97] Work-related stress, poor job quality and burnout syndrome have all been correlated with higher allostatic load.[97] Allostatic load is inversely related to neighborhood socioeconomic status,[7] with lack of vegetative land cover, perception of pollution, household crowding, and poor indoor environmental quality all being associated with increased allostatic load scores.[97]

Financial security, socioeconomic status and education levels have also been consistently shown to be inversely related to allostatic load.[7,96–98] Having lower income has been significantly associated with a 1.60 times increased likelihood of higher allostatic load (95% CI: 1.2, 2.0) in Canada,[15] with similar associations being seen in the United States.[14] Ethnic minority populations experience higher allostatic load in general,[7,97] despite socioeconomic gradients being seen across all ethnicities.[7] Allostatic load increases with age before leveling off around retirement,[15,99] and both the age-related increase and the leveling off appear to be more pronounced in men than in women.[15] This suggests there exists a sex-related difference in allostatic load distribution and determination,[7] with men exhibiting higher allostatic load across the life course. The

levelling off, could be attributable to the survival effect, with premature death removing the contribution of the highest allostatic load scores on its distribution among the oldest survivors.[15]

2.4.3. Allostatic Load and Health Outcomes

Having increased allostatic load has been shown to be a powerful predictor of numerous poor health outcomes. Higher allostatic load scores are associated with mental disorders such as self-rated stress and psychological distress,[97] and general cognitive decline.[15,93] Physical declines, including musculoskeletal disorders and frailty, have been associated with higher allostatic load,[15,97] as have several serious morbidities including cardiovascular diseases[15,93,97] and diabetes.[97] As a result, all-cause mortality and allostatic load are closely and positively related,[15,93,100,101] with mortality rates having been shown to increase by as much as 40% with a one-point increase in allostatic load score.[100]

It has been suggested that allostatic load may also be a useful preclinical marker of frailty.[97] Among American seniors, a 1-point increase in allostatic load score has been associated with 1.16 times the odds of being frail (95% CI: 1.04, 1.38)[102] and 1.10 times the odds of developing frailty within 3 years (1.10, 95% CI: 1.03, 1.19)[103]. In the United Kingdom, a 1.0 standard deviation (SD) increase in allostatic load (approximately 1.5 allostatic load units) was shown to predict a 0.108 SD increase in physical frailty two years later[104] in a study where the mean population frailty only increased 0.06 SD over the same period. Although some studies operationalize different allostatic load indices, modern laboratory-based frailty indices (FI-Labs) share similarities with Statistics Canada's definition of allostatic load.[15] Across three recently validated FI-Labs,[105–107] the only allostatic load biomarker not found in at least one index was waist-to-hip ratio. Despite this, the concepts allostatic load and frailty try to assess remain distinct. While frailty develops from age-related decline across physiological systems,[108] allostatic load is relevant across the life course and represents the physiological manifestation of chronic psychosocial stressors, such as financial insecurity, over time. Given the changes in health, income, and lifestyle that accompany aging and later life, further examination of allostatic load in older adults could provide interesting insight into the relationship between socioeconomic status, financial security, and health as individuals age.

2.5. Summary

A GAI represents a simple and attractive income intervention that holds the potential to significantly improve the financial well-being of many low-income Canadians. Given the well-established relationship between financial resources, income inequality, and health, such an intervention also has the theoretical potential to greatly improve both the health of vulnerable individuals, and population health overall. OAS, the only Canadian analogue to a GAI, has been previously associated with reductions in food insecurity and improvements in self-rated health, and this study aimed to investigate whether similar improvements would be seen in allostatic load. There were several gaps in the literature which this study aimed to fill. Firstly, the lack of modern evidence on the health impacts of a GAI in Canada remains considerable. MINCOME concluded more than 40 years ago,[70] and the Ontario Basic Income Pilot lasted less than two years,[71] so much of the Canadian evidence that exists is incomplete or significantly dated. GAI and OAS are ever relevant to Canadian political discussions, so this research aimed to provide timely, contemporaneous evidence about the potential health benefits they hold. Secondly, few Canadian studies have examined the impact of OAS using an objective health measure. Previous research on OAS had focused almost exclusively on measures self-reported outcomes (e.g., general health and food insecurity). The use of an objective health measure such as allostatic load builds on previous findings and represents an important next step in determining the extent to which OAS and GAI programs can act as a public health intervention for some of Canada's most vulnerable populations.

CHAPTER 3: OBJECTIVES

The overall goal of this study was to examine the associations between objective health measures and receiving a guaranteed annual income in Canada, using allostatic load data from the Canadian Longitudinal Study on Aging (CLSA). Existing evidence continues to demonstrate the relationships between income, income inequality and health, but the associations between Old Age Security, a known poverty-reduction solution, and health remain less established. Using objective outcomes, I aimed to complement previous evidence and provide a clearer understanding of the health benefits of OAS. This could have significant policy implications and lead to potential improvements in health for many of Canada's most vulnerable and at-risk populations.

To meet this overall goal, four objectives were set:

1. Objective One: characterise allostatic load, along with financial, sociodemographic, and health features of older Canadian adults based on age and sex.

2. Objective Two: investigate the relationships between allostatic load and income, homeownership, savings, and overall financial security.

3. Objective Three: estimate the association of Old Age Security and allostatic load by level of financial security.

4. Objective Four: estimate the association of Old Age Security with allostatic load across the population distribution within financially insecure older adults.

It was hypothesized that allostatic load, my measure of objective health, would be lower (i.e., better) on average for individuals of higher income, higher savings, those who owned a home, and those classified as financially secure. Mean allostatic load has been shown to be consistently patterned by socioeconomic measures,[97] increase with age, and be higher in males than females;[15] this was anticipated to be similarly true in this study population.

For the second objective, it was hypothesized that lower levels of income, savings, and homeownership, along with overall financial security, would all be associated with higher allostatic load scores. This is consistent with similar research on this topic which have employed similar analytical techniques.[15]

For the third objective, it was hypothesized that OAS would modify the relationship between financial security and allostatic load. Based on known associations between low financial resources and poorer health[13] and the associations of OAS and health-improvements seen the past,[3] the combination of receiving OAS while being financially insecure was anticipated to be associated with improved allostatic load in this group.

Finally, OAS was hypothesized to have its greatest association with improved health in those with the worst health, acting to narrow the population distribution of allostatic load amongst financially insecure older adults. This is consistent with previous research on the health benefits of interventions of similar scale to OAS.[60,63]

CHAPTER 4: METHODS

4.1. Data Source and Study Population

The Canadian Longitudinal Study on Aging (CLSA) is a national cohort study developed to examine health trajectories of older adults and seniors from ages 45 to 85 and improve the health of populations as they age.[109] It contains a range of economic, biological, and lifestyle indicators and, in a sub-cohort, biospecimen and physical examination information. This dataset is therefore ideal for examining relationships between income-related variables, financial security, and allostatic load.

The CLSA consists of two cohorts, Tracking and Comprehensive, totalling 51,338 Canadians between the ages of 45 and 85. Both cohorts complete the same core questionnaire which covers demographic, social, clinical, psychological, economic and health status measures. Participants were recruited through three sampling frames: the Canadian Community Health Survey, Provincial Health Registration Databases, and random digit dialing, and eligible individuals were identified based on age and sex strata. When individuals were successfully contacted and informed consent was obtained, they were recruited into the study. Exclusion criteria included the inability to complete the interview in English or French, living with a cognitive impairment, residing in a long-term care home, the three territories, or federal First Nations reserves, holding a temporary visa, or being a full-time member of the Canadian Armed Forces.[109] The CLSA aims to continue to collect follow-up information from participants every 3 years until 2033; baseline data collection was completed in 2015, and a first follow-up was completed in 2018.

The CLSA Tracking cohort is made up of 21,241 participants, representing different areas of residence across all 10 provinces. All data for the CLSA Tracking is collected using computer-assisted telephone interviews.

The CLSA Comprehensive cohort is made up of 30,097 participants who live within a 25-50km radius of a data collection site (DCS) as specified during sampling through identification of ‘acceptable’ postal codes. The CLSA has DCSs in eleven cities across

seven Canadian provinces: British Columbia, Alberta, Manitoba, Ontario, Quebec, Nova Scotia, and Newfoundland. Core data for the CLSA Comprehensive is collected using computer-assisted personal interviews, while physical assessments and biospecimen collections are performed at data collection sites. The CLSA is national in scope but is not nationally representative due to the requirements and locations of DCSs. Sampling weights are provided for each participant based on their inclusion probability, to estimate how many people in each province (and in Canada) they represent. This ensures estimates of Canadian population means or proportions are not skewed towards provinces or sub-groups with higher proportions of participation.[109,110]

Among the physical assessments and biospecimens collected in the Comprehensive cohort are the nine biomarker variables required to develop an allostatic load index according to Statistics Canada guidelines. Consequently, this study uses the Comprehensive cohort only. The CLSA Comprehensive follow-up data had not yet been made available, so this study was limited to only the baseline data and thus a cross-sectional study design.

4.2. Exclusion Criteria and Missing Data

All participants aged less than 55 years or greater than 75 years were excluded from the study (n=12,173) to centre our sample around 65 (the age of eligibility for OAS) and ensure all observations were relevant to the research question. Those missing any of the nine variables required to make the allostatic load index were also removed (n=2,045). If a variable other than allostatic load had missing data of more than 1% of the initial sample, a missing category was created for that variable. When a variable was missing less than 1% of the initial sample, participants missing scores for that variable were removed (n=170). Income-related variables were the exception to this rule, and missing categories were created for each of the income-related variables regardless of the size of the missing category. This was done because the financial security composite variable was able to categorize participants using a minimum of one income-related variable (more below). As a result, only those missing all three income-related variables (total household income, total savings, homeownership status) used in the financial security

composite variable were removed (n=18). This left a final study sample of 15,691 participants.

4.3. Description of Variables

4.3.1. Allostatic Load

The CLSA Comprehensive dataset contains all information required to develop an allostatic load index score for all participants. Allostatic load, as defined by Statistics Canada,[15] is made up of four metabolic indicators (total cholesterol, high-density lipoprotein, glycated hemoglobin, waist-to-hip ratio), three cardiac indicators (average systolic blood pressure, average diastolic blood pressure, average pulse rate), and two inflammatory indicators (C-reactive protein, albumin).

For each biomarker making up allostatic load, participants were assigned dichotomous risk indicators (high or not). A high-risk designation corresponded to a score of 1 for that biomarker, while those who did not receive a high-risk designation received a score of 0. A participant's allostatic load score was the sum of all high-risk indicators from 0-9. Higher values are therefore indicative of greater physiological dysregulation. There were two independent methods for assigning high-risk designations, one using clinical cut-offs and one using empirical cut-offs.

a) *Clinical cut-offs:* high-risk indicators were assigned based on Statistics Canada definitions[15] and widely accepted clinical cut-offs from the literature. Any value outside the clinical cut-off for what is considered clinically "healthy" was assigned a high-risk indicator for that variable.

b) *Empirical cut-offs:* high-risk indicators were assigned based on the unique distribution of each variable within the sample. Depending on the variable, the value that corresponded to either the 25^{th} or 75^{th} percentile was identified and became the high-risk cut-off for that biomarker. Low granularity of variables meant that in some cases more than 25% of the sample was coded as high risk (e.g., albumin).

Each variable used in the allostatic load index is detailed below.

Total Cholesterol - Total cholesterol is a combined measure of both low- and high-density lipoprotein cholesterol. High levels of total serum cholesterol are an established risk factor for incident coronary heart disease, cardiovascular disease, and stroke.[111,112] The high-risk clinical cut-off for total cholesterol included all values above 6.208mmol/L;[15] the high-risk empirical cut-off included all values greater than or equal to 5.92mmol/L.

High Density Lipoprotein (HDL) - High density lipoprotein specifically promotes reverse cholesterol transport, and has many antioxidant, anti-inflammatory, and anti-thrombotic properties[113]. Its beneficial function mean it has an inverse relationship with cardiovascular disease; low levels of HDL are associated with increased cardiovascular risk and atherosclerosis.[112] The high-risk clinical cut-off for high density lipoprotein included all values below 1.034mmol/L;[15] the high-risk empirical cut-off included all values less than or equal to 1.150mmol/L.

Glycated Hemoglobin (HbA1c) - Glycated hemoglobin is a surrogate marker of an individual's glycemic control and a key factor in the diagnosis of diabetes.[114] Concentrations are affected by the blood glucose concentration, the duration of red blood cell exposure to various concentrations, and the quantity of red blood cells.[114] An individual with a HbA1c concentration of above 6.4% is considered diabetic, while a concentration between 5.7%–6 .4% is indicative of a prediabetic state. Increased HbA1c concentrations are a strong predictor of cardiovascular events and mortality in patients with diabetes but are unlikely to be a strong predictor in patients without established diabetes.[114] The high-risk clinical cut-off for glycated hemoglobin concentration included all values above 6.4%;[15,114] the high-risk empirical cut-off included all values greater than or equal to 5.8%.

Waist-to-Hip Ratio (WHR) - An individual's waist-to-hip ratio is an anthropometric measure of abdominal or central obesity. WHR has been shown to be a better predictor of poor health outcomes than other anthropometric measures, such as one's BMI,[115] as it effectively quantifies not only body fat, but its storage location and metabolic activity. An elevated WHR is a strong predictor of cardiometabolic risk, including myocardial infarction.[115] WHR is a better predictor of myocardial infarction in women than men, as it

captures important sex-based differences in body composition. As a result, the cut-offs differed based on sex. The high-risk clinical cut-off for WHR included all values above 0.85 for females, and 0.90 for males;[15] the high-risk empirical cut-off included all values greater than or equal to 0.88 for females, and 1.02 for males.

Systolic and Diastolic Blood Pressure - Increased systolic and diastolic blood pressure, two measures of force the heart exerts as it beats, both have established associations with increased cardiovascular risk. An increase in systolic blood pressure (SBP) from 115mmHg to 135mmHg, or an increase in diastolic blood pressure (DBP) from 75mmHg to 85mmHg, have both been shown to double the risk of cardiovascular disease, angina, myocardial infarction, heart failure, stroke, and peripheral artery disease.[116] The relative risk of incident cardiovascular disease due to high SBP and DBP is smaller at older ages. However, given that age increases the absolute risk of cardiovascular disease, high blood pressure further compounds this absolute risk.[116] Therefore, high systolic and diastolic blood pressures are particularly relevant to this study population. The high-risk clinical cut-offs included all values above 140mmHg for SBP, and 90mmHg for DBP;[15] the high-risk empirical cut-offs included all values greater than or equal to 132.5mmHg for SBP, and 81mmHg for DBP.

Resting Heart Rate - An individual's resting heart rate is a sensitive indicator of their autonomic nervous system and overall health. Increases in resting heart rate have been associated with type two diabetes, cardiovascular risk, total cancer, and sudden cardiac death.[117] To quantify this, an increase of 10bpm has been associated with a 18% increased relative risk of heart failure, and a 17% increased relative risk of all-cause mortality.[117] The high-risk clinical cut-off for resting heart rates included all values above 90bpm;[15] the high-risk empirical cut-off included all values greater than or equal to 78.5bpm.

C-Reactive Protein (CRP) - C-reactive protein is an acute inflammatory protein that elevates its expression, sometimes more than 1000-fold, in response to infection or inflammation.[118] The average C-reactive protein concentration is 0.8mg/L, and increased expression of CRP has been seen in response to inflammatory conditions such as rheumatoid arthritis, appendicitis, pancreatitis, and meningitis.[118] Continually elevated

levels of C-reactive protein above 3mg/L is considered a predictive marker for cardiovascular disease and has been linked prognostically in patients with congestive heart failure, atherosclerotic disease, and heart transplantation.[118] The high-risk clinical cut-off for C-Reactive Protein included all values above 3mg/L;[15,118] the high-risk empirical cut-off included all values greater than or equal to 2.8mg/L.

Albumin - Albumin is the most abundant plasma protein, accounting for more than half the body's serum composition.[119] It plays important antioxidant, anti-inflammatory, transport and metabolic roles in the body, and reductions in serum albumin concentrations are indicative of critical illness and malnutrition.[120] Hypoalbuminemia is predictive of major cardiovascular events, including ischemic heart diseases, heart failure, atrial fibrillation, and stroke.[119] The high-risk clinical cut-off for serum albumin concentration included all values below 38g/L;[15] the high-risk empirical cut-off included all values less than or equal to 38g/L.

All biomarkers used for the allostatic load index were measured at a DCSs using appropriate instrumentation. Consistent with the literature, high allostatic load scores were rare.[7,15] As a result, higher values of allostatic load were condensed to a "5+" group for the clinical allostatic load index, and an "6+" for empirical allostatic load index for all analyses, as has been previously suggested.[15]

Medication Considerations

Medication was an important consideration for the development of an allostatic load index. Medical treatments for certain conditions (e.g., hypertension), may act to lower an individual's biomarker reading below a high-risk cut-off, resulting in the assignment of a lower allostatic load score despite the presence of a health issue requiring treatment. Previous allostatic load literature has identified this concern, and methods to address it include manually adjusting biomarker values based on the type of medication an individual is taking,[35] or recreating an allostatic load index with only medication information for a sensitivity analysis.[121] Taking medication into account when assigning high-risk classifications, however, has not yet been shown to significantly change results compared with using absolute values alone.[15,121]

Regardless, this study provided a good opportunity to further investigate this issue. To do this, the above approaches were combined, and values of biomarkers were altered based on medication use to create an adjusted allostatic load index which was used for a sensitivity analysis. Because of data limitations, only select medication information was available for participants. This included a list of conditions for which participants were taking medication, but no information on the type of medication itself. Due to the variety of medications that can be used to treat any given condition, only two relationships were conclusively inferred between receiving medication for a condition and an appropriate biomarker adjustment. The two conditions used were hypertension and diabetes. Following previous work, when participants reported taking medication for hypertension, their systolic and diastolic blood pressures were adjusted by adding 10mmhg and 5mmHg,[122,123] and when taking diabetic medication, 1% (as a percentage of blood content) was added to their glycated hemoglobin levels.[123,124] At the conclusion of the main analysis, all models were repeated using the adjusted allostatic load indices as the outcome variable, and were assessed for any differences from the main results.

4.3.2. Income-Related Variables

Total Personal Income

This variable categorised the total personal income of the participant. Participants were asked "What is your best estimate of your total personal income received, from all sources and before taxes and deductions, in the past 12 months?" Responses were then classified into one of five possible categories: (0) <$20k, (1) $20k-$50k, (2) $50k-$100k, (3) $100k-$150k, or (4) $150k+.

Total Household Income

This variable categorised the total household income of the participant. Participants were asked "What is your best estimate of the total household income received by all household members, from all sources and before taxes and deductions, in the past 12 months?" Responses were classified into one of five possible categories: (0) <$20k, (1) $20k-$50k, (2) $50k-$100k, (3) $100k-$150k, or (4) $150k+.

Homeownership

Home ownership was used as a measure of non-liquid wealth that, through buffering against income shocks, may contribute significantly to an individual's financial security. With retirement, older adults may report a decreased income while still holding a sizeable asset such as a home. Although information about other asset ownership was available, individuals who do not own their own dwelling are probably far less likely to own additional assets (i.e., secondary home, valuable jewellery etc.), so home ownership was used as a baseline measure of important asset ownership.

Participants were asked a series of three questions: "What type of dwelling do you currently live in?", "Do you (or your spouse/partner) own or rent your dwelling?" and, if their dwelling was owned, "Is this with a mortgage or is your mortgage paid off completely?". A home ownership variable was developed from these three variables, classifying participants into one of three levels: (0) Does not own their home, (1) owns home with a mortgage, or (2) owns home without a mortgage.

Total Savings

The total estimated value of a participant's (and their spouse/partner's) total savings was used as a measure of liquid wealth that could also provide financial security. Savings are particularly relevant given those with less likely rely more heavily on OAS and draw from the program as soon as they become eligible to do so.[125] The total savings variable was developed by combining two wealth variables. Participants were asked "Which, if any, of the following savings and investments do you (and your spouse/partner) have?" and "What is the approximate total value of these savings and investments?" Participants who answered "None" to the first question were not asked the follow-up, and these two variables were combined to create a total savings variable. Participants were classified into one of four levels: (0) <$50k (which included none), (1) $50k–$100k, (2) $100k–$1m, (3) $1m+.

OAS as Highest Personal/Household Income Source

Highest personal and household income source were also available within the CLSA. Participants were asked to specify their highest source of income from a list of 17 possible sources. OAS and GIS were both options to be selected. Since GIS is a subsidiary program of OAS, these two levels were combined, and a dummy variable was created. Participants highest personal and household income source was classified into either (0) Non-Pensions/Other, or (1) OAS.

Total Personal Income, Total Household Income, Total Savings, and Homeownership Status are referred to collectively as "income-related variables" for brevity throughout this study.

4.3.3. Financial Security Composite Variable

A financial security composite variable was created to capture less well-off participants more accurately, and model low income, low savings, and lack of homeownership together. For older populations, the low-income high-wealth paradox means a retired individual could report an annual income of less than $20k but still own their home and have a large portfolio of savings and investments. As such, income alone may be a poor measure of overall financial stability and consumption. The financial security composite variable provides a more comprehensive measure of the total financial resources available to participants, which in turn facilitates a better understanding of the relationship between a fewer financial resources and allostatic load. Determining the appropriate income variable to use in the financial security composite variable was a practical consideration. Personal income does not reflect the income of others in a household, an important consideration when discussing the overall financial security one experiences and its association with health. Total household income was therefore included in the financial security composite variable as it better reflects an individual's overall financial means.

Three financial security composite variables were developed, beginning with strict inclusion criteria and becoming more inclusive. Each financial security composite variable was a binary dummy variable, classifying individuals as either financially secure or financially insecure according to their total household income, total savings, and home

ownership status. The development of the financial security composite variables are described below:

1) *Financially Insecure (Strict):* Participants considered to be 'financially insecure' if they report a total household income <$50k, total savings <$50k, and do not own their home.

2) *Financially Insecure (Moderate):* Participants considered to be 'financially insecure' if they report a total household income <$50k, total savings <$100k, and do not own their home.

3) *Financially Insecure (Inclusive):* Participants considered to be 'financially insecure' if they report a total household income <$50k, total savings <$100k, and do not own their home outright (i.e., rent, or own home with a mortgage).

Individuals with missing information on one or more of these three variables were assigned a financial security group based on the information that was available. For example, a participant who reported savings of less than $50k but was missing both total household income and homeownership information, would still be classified as financially insecure in all three of the above composite variables. One exception to this rule was for the financial security (inclusive) composite variable, where for 64 participants, the only financial information available was that they owned their dwelling with a mortgage. This was considered insufficient to confidently classify them as financially insecure, therefore they were not.

By way of other variables, the total household income of <$50k was used as the base cut point for financial insecurity. This best matches the economic requirements for GIS qualification (the highest total household income still eligible for GIS under the OAS system is $47,136, with some conditions),[77] along with the MBM[47] and LICO[48] for Canadian households. The cut points for savings and home ownership were chosen due to practical considerations and their low position relative to the other levels of the variable. The relationship between allostatic load and all three financial security composite variables was modeled in objective two and based on these results (along with sample

size considerations), one was selected for analyses that addressed objectives three and four.

4.3.4. Sociodemographic Characteristics

Age

Participant's age was available in the CLSA. Only participants between the ages of 55 and 75 were included, centering the study population around 65, the age of eligibility for OAS. Age is known to be associated with allostatic load[15] and was a crucial component to this study. To allow for comparisons, descriptive statistics were stratified by age (less than 65 vs 65 and older), while all models controlled for age by way of a continuous variable. An age-squared term was explored in all models but was removed from the model when not statistically significant and no major role in the outcome of the model was observed.

Sex

Sex information of all participants was collected during the survey. This is an obviously important consideration as allostatic load, and its lifetime trajectory, has been shown to differ between males and females.[15] Males tend to have higher allostatic loads earlier in life before it plateaus around retirement; females tend to have a slower, but consistently linear, increase throughout the life course.[15] Although allostatic load does appear to increase with age in all cases,[15,99] the literature indicated there could be important differences between men and women. Participants were classified as (0) female or (1) male, and all analyses were stratified by sex.

Marital Status

Previous studies in this area have focused on low-income singles due to their vulnerability to poverty and poverty-related poor health outcomes.[126,127] As a result, marital status was an important covariate to control for in all analyses. Participants were asked about their marital status, which was recorded in the CLSA as a five-level categorical variable. This was condensed into a binary variable for the purpose of this study: (0) Single/Widowed/Divorced or (1) Married/Living with partner.

Education

To assess educational attainment, participants of the CLSA were asked a series of three questions: “Did you graduate from high school (secondary school)?” “Have you received any other education that could be counted towards a degree, certificate, or diploma from an educational institution?” and “What is the highest degree, or certificate, or diploma you have obtained?” Participants who, for example, did not graduate high school, were not asked any further questions. These three variables were then combined to create a five-leveled education variable: (0) Less than high School, (1) High School Graduate, (2) Diploma/Certificate, (3) Bachelor’s Degree, (4) Above Bachelor’s Degree.

Retirement Status

Retirement status was an important covariate to control for in the analysis to control for the possibility of retirement-related changes in health. To do this, we used self-reported retirement status as recorded within the CLSA. Participants were asked about their retirement and were categorized into either (0) Not Retired, (1) Partially Retired, or (2) Completely Retired.

Visible Minority Status

Participants were asked about their cultural and racial backgrounds and given a list of 17 options which they could select. To control for ethnicity, a visible minority status variable was developed in the form of a binary variable, with participants being classified as either (0) Non-Visible Minority or (1) Visible Minority.

Province of Residence

The province of residence for each participant was obtained from their Canadian-issued health card. Due to the locations of the DCSs, only seven provinces are represented within the sample. Individuals were assigned to their corresponding province of residence: British Columbia, Alberta, Manitoba, Ontario, Quebec, Nova Scotia or Newfoundland.

4.3.5. Health Characteristics

Chronic Conditions

Participants were asked a total of 42 questions about whether they have been told by a physician they have a chronic disease. Chronic diseases they were asked about include, but are not limited to, heart disease, diabetes, epilepsy, cancer, and poor mental health. From this, a derived variable provided by the CLSA was used to categorize participants into either having (0) No chronic conditions or (1) at least one chronic condition.

Smoking Status

Participants were asked a series of questions about their smoking habits. From this information, a smoking variable was developed which classified participants into one of four levels: (0) Never Smoked, (1) Former Smoker, (2) Occasional Smoker, or (3) Current Daily Smoker.

Alcohol Consumption

Participants were asked several questions about their alcohol consumption. From this information, an alcohol consumption variable was developed which classified participants into one of three levels: (0) Regular Drinker, (1) Occasional Drinker, or (2) Non-Drinker.

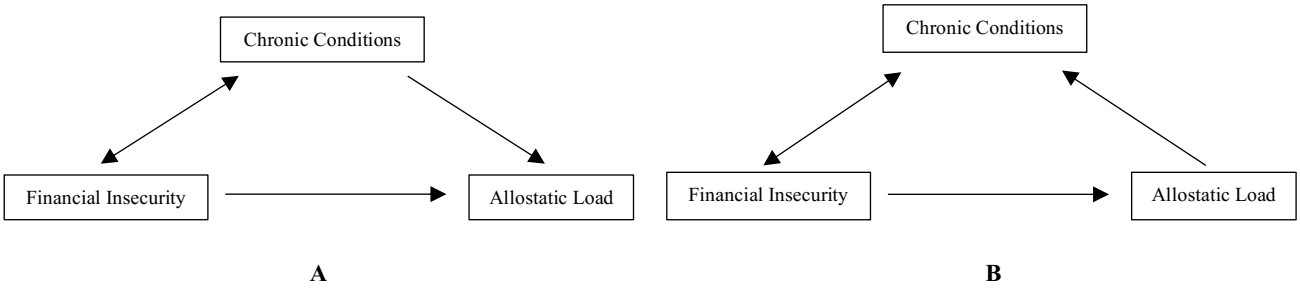
4.4. Theoretical Framework

The fundamental relationship of interest in this study was between the exposure financial insecurity and the outcome allostatic load. Before assessing how this association was modified by OAS, a policy intervention, a theoretical model for this underlying relationship and its covariates was established. In this study, financial security was approached as an overall measure of financial resources which, when lacking, may impact a host of everyday life events, for example paying rent or purchasing groceries. Experiencing a variety of financially related acute stressors may manifest over time into elevated allostatic load as has been previously suggested.[7,96–98] In order assess this association, sociodemographic and health characteristics were included in the model to address potential confounding. Confounding variables are variables that may influence

both the exposure and the outcome and, when not properly controlled for, can bias the results of an analytical model. The covariates listed above could all conceivably have an influence on both financial insecurity and allostatic load, and were included in the model to control for their respective potential associations.

Chronic conditions, however, presented an analytical dilemma. While associated with both the exposure and outcome, the particularly close relationship between chronic conditions and allostatic load raised the concern that this variable may be on a causal pathway. However, without controlling for them, chronic conditions could artificially inflate allostatic load in financially insecure individuals and potentially bias upwards any association seen between financial insecurity and allostatic load. Such a dilemma is highlighted in discussions around the inclusion of "good controls" and "bad controls" in statistical models.[128] Consider Figure 1:

Figure 1. Theoretical Mechanism behind Financial Insecurity, Allostatic Load and Chronic Conditions



In situation A, financial insecurity and chronic conditions are associated with each other, while chronic conditions influence allostatic load. Here chronic conditions are a confounder; controlling for confounders is important to avoid spurious associations and biased regression estimates. In this context, analytical models should control for chronic conditions (i.e., they are a good control). In situation B, while financial insecurity and chronic conditions remain associated with each other, allostatic load now influences chronic conditions. Here, both financial insecurity and allostatic load may have common effects on chronic conditions, which is now a collider. In this context, analytical models should not control for chronic conditions (i.e., they are a bad control).

Ultimately, a pragmatic consideration of both situations led to the treatment of chronic conditions as a confounder (i.e., a good control) in the relationship between financial

insecurity and allostatic load. This meant chronic conditions were controlled for in all models alongside the other covariates, minimizing the risk of it artificially inflating allostatic load scores and biasing the relationship of interest. However, the collider situation was not totally disregarded. At the conclusion of the main analysis, a sensitivity analysis repeated all models with chronic conditions removed (i.e., treating chronic conditions as a bad control), and assessed them for any differences from the main results.

4.5. Analysis

Ordered logistic regression assessed the association of allostatic load, the dependent variable, with income-related variables, financial security, and OAS (along with controls). This is a useful regression technique for categorical and meaningfully ordered outcome variables, such as allostatic load, and assigns the probability of having higher or lower scores relative to a certain threshold or level of the ordered dependent variable. From such a model, odds ratios for having an allostatic load score higher or lower than this level can be obtained, based on levels of the independent variables that are incorporated. The basic ordered logistic regression between allostatic load and financial security, for example, is modelled as:

$$logit(P(AL > j) = \beta_{j0} + \beta_{FS}\chi_{FS} + \beta_{C}\chi_{C}$$

Here, *AL* stands for allostatic load with *J* categories (6 in the case of clinical allostatic load; 7 in the case of empirical allostatic load). Any given allostatic load score is represented by *j*, and $P(AL \leq J) = 1$. X_{FS} represents financial security and its coefficient β_{FS}, X_c represents all controls and their coefficients β_C, and β_{j0} is the intercept term for each category. Through modelling this equation, probabilities and odds ratios can be obtained for having a higher allostatic load relative to any given reference allostatic load score (j) based on levels of the independent variable (X_{FS}) while holding everything else (X_C) constant. This basic model was used to address objectives two and was further expanded on to address objective three as outlined below.

4.5.1. Objective One

To meet the first objective, *characterise allostatic load, along with financial, sociodemographic, and health features, of older Canadian adults based on age and sex,* descriptive statistics are reported. These include the proportions of participants who fall into each level of each variable, along with mean allostatic load scores of the study population. Cross tabulations show the distribution of allostatic load, using both clinical and empirical allostatic loads, across levels of individual income-related variables, financial security, sociodemographic characteristics, and other covariates. This provides an initial examination of socioeconomic, financial, and sex-based gradients in mean allostatic load scores. Selected gradients are presented as figures.

Further descriptive statistics presented include mean values of the individual biomarkers which make up allostatic load and their corresponding units, along with the distribution of both clinical and empirical high-risk groups presented as the proportion of participants classified as high-risk for that biomarker. Age is considered a two-leveled categorical variable for the presentation of descriptive statistics – less than 65 and greater than 65 – allowing for a comparison of groups loosely defined as pre- and post-OAS eligibility.

4.5.2. Objective Two

To meet the second objective, *investigate the relationship between allostatic load and income, homeownership, savings, and overall financial security,* the crude association between allostatic load and individual income-related variables was first modeled using ordered logistic regression. Unadjusted models established relationships between (clinical and empirical) allostatic load and total personal income, total household income, total savings, home ownership, and all three of the financial security composite variables. Fully adjusted models are presented and control for the following sociodemographic and health characteristics: marital status, educational attainment, retirement status, visible minority status, province of residence, presence of chronic conditions, smoking habits and alcohol consumption.

The need for sex-specific stratification was confirmed by including an age-sex interaction term in the pooled model; as a result, all models are stratified by sex. An age-squared

interaction term was also explored to adjust for the potential of a non-linear relationship between age and allostatic load as suggested previously.[15] This was removed from female-stratified models but remained in male-stratified models. All ordered logistic regressions used the condensed allostatic load indices, with the highest category being "5+" for clinical allostatic load, and "6+" for empirical allostatic load.

4.5.3. Objective Three

To meet the third objective, *estimate the association of Old Age Security and allostatic load by level of financial security,* I present expanded ordered logistic models from those established in objective two. Additional considerations were required to investigate the differential associations of OAS with allostatic load in older adults based on their level of financial security.

Assuming a relationship existed between financial insecurity and allostatic load, this relationship had the potential to be modified by receiving OAS. The financial security composite variable was interacted with the variable indicating OAS as highest personal income source, and odds ratios were obtained to assess and compare the association between the independent variables and their interaction with allostatic load. OAS as highest personal income source (as opposed to household income) was used for this analysis, as OAS is first and foremost a personal benefit, and allostatic load is a personal outcome. Overall financial environment had already been accounted for through the financial security composite variable.

The crude association between empirical and clinical allostatic load and the interaction term was modeled using simple ordered logistic regression, followed by adding further covariates into the model as was done in objective two. Age and age-squared terms were also included in this model, and once more the age-squared term was removed when not statistically significant and had no major role in the outcome of the model. All multivariate models remained stratified by sex. Odds ratios and confidence intervals from the fully adjusted models are presented.

From these regression coefficients, the fitted marginal probabilities of financially insecure older adults having any given allostatic load score are presented graphically

using predictive margins. This allows for a direct visual comparison of the differences in expected allostatic load scores between financially insecure older adults who reported OAS as highest personal income source versus those who did not, and provides further insight into the interaction term in general.

4.5.4. Objective Four

To address objective four, *estimate the association of Old Age Security with allostatic load across the population distribution within financial insecure older adults,* the interaction term specified above has been modelled across the distribution of allostatic load using unconditional quantile regression (UQR). This regression technique allowed the analysis of potentially heterogeneous parameter estimates across the population distribution of allostatic load, to see in which deciles of allostatic load the associations are the strongest.

UQR estimates the impact of changes in the exposure variable(s) on the unconditional quantiles of the outcome, and thus models changes in distributional statistics such as the median (i.e., other than the mean). The use of "unconditional quantiles" is not related to model adjustment or lack of covariates; unconditional quantiles refer instead to quantiles of the marginal distribution of the outcome. The main innovation of UQR versus other quantile regression techniques is to use ordinary least squares to estimate the model which allows for interpretation of the marginal probabilities.[129] Functionally, this means that several regressions are run at pre-specified quantiles of the outcome, and the differences or trends in these estimated coefficients across the distribution of the outcome are assessed.

The unconditional quantile regression was conducted using the same model specified in objective three, where Y would refer to the interaction term and X is allostatic load. The regression quantiles specified began at 0.10 (i.e., the 1st decile), and increased in increments of 0.05 until 0.90 (i.e., the 9th decile). This produced 17 estimated coefficients, which are presented graphically. Visually displaying the changes in magnitude and direction of the estimated interaction coefficients across the distribution of allostatic load allowed for an easier identification of the financially insecure older adults

who benefit the most from receiving OAS as highest personal income source. All models remain stratified by sex.

All descriptive statistics presented (proportions and means) are weighted using inflation weights, and all analyses are weighted using analytic weights, as provided and instructed by CLSA resources.[110] Standard errors were estimated, and statistical significance was set at the 5% level ($p < 0.05$). All analyses were conducted in STATA 16.

CHAPTER 5: RESULTS

5.1. Objective One: Summary Statistics

A total of 15,691 participants made up the final study sample after 14,406 participants were removed. Participants were excluded for being outside the age range (n=12,173) or due to missing data (n=2,233). Participants were removed due to missing data if they were missing one or more of the allostatic load biomarkers (n=2045), missing all three of the income-related variables required for the financial security composite variable (n=18), or missing covariate information where the missing group was less than 1% of the original sample size (n=170). The missing sample had a greater proportion of women (58.17%) than the analytical sample (51.04%), and greater proportions of financially insecure participants across all financial security levels compared with the analytical sample (11.71%, 13.41% and 20.96% vs. 6.71, 7.84% and 12.44% for strict, moderate, and inclusive definitions). The weighted mean age of the missing sample (63.57 years) was equivalent to the analytical sample (63.42 years), and provincial distributions were similar throughout.

The final study population was made up of 51.04% females and 48.96% males, with the majority of both males (63.26%) and females (59.92%) aged less than 65. Overall, the sample population appeared quite healthy, financially secure, and well-educated. In terms of allostatic load, 80.50% of females and 71.25% of males had a clinical allostatic load score of 2 or less, while 79.96% of females and 76.80% of males had an empirical allostatic load score of 3 or less (empirical allostatic load scores were, on average, higher than clinical scores). In total, 76.22% of males and 61.91% of females reported a total household income of greater than $50k, including 19.05% of males who reported a total household income of more than $150k annually. The majority of the study population owned their own home outright (58.20% of males; 57.65% of females), reported savings of more than $100k (63.75% of males, 50.66% of females), and were classified as financially secure by all definitions (90.70% of males and 84.54% of females).

5.64% of females and 3.34% of males reported a total household income of less than $20k, 20.71% of females and 15.61% of males did not have savings exceeding $50k, and

14.63% of females and 11.21% of males did not own their own home. Just 6.17% of females and 2.23% of males reported OAS highest source of personal income.

The study population was also well educated. In total, 80.46% of males and 74.68% of females reported some form of education after high school, 40.20% of females reported a bachelor's degree or higher, and 26.27% of males reported education exceeding that of a bachelor's degree. Only 6.81% of females and 5.11% of males did not graduate high school. More females reported being completely retired (53.61%) than males (42.85%), and the majority of the population reported at least one chronic condition, regular drinking, and not being a smoker. A full summary of weighted sample characteristics can be found in Table 1.

Table 1 Sample Characteristics by Sex (weighted)
(n= 15691)

		Female		Male	
		N	**%**	**N**	**%**
All		7849	51.0%	7842	49.0%
Age					
	55-64	4412	59.9%	4251	63.3%
	65-75	3437	40.1%	3591	36.7%
Clinical Allostatic Load Score: (Literature-based cut-offs)					
	0	1911	25.7%	423	5.5%
	1	2517	32.3%	2659	35.3%
	2	1804	22.6%	2373	30.4%
	3	1004	12.3%	1399	17.1%
	4	417	5.1%	667	8.1%
	5+	196	2.1%	321	3.7%
Empirical Allostatic Load Score (Sample-based cut-offs)					
	0	989	13.4%	930	12.6%
	1	1980	25.7%	1610	21.5%
	2	1864	24.0%	1865	23.8%
	3	1333	16.8%	1503	18.9%

Table 1 Sample Characteristics by Sex (weighted)
(n= 15691)

	Female		Male	
	N	**%**	**N**	**%**
4	910	11.0%	1026	12.2%
5	490	5.8%	550	6.8%
6+	283	3.3%	358	4.2%
Income (Personal)				
<$20k	1700	23.4%	648	8.3%
$20k-$50k	3294	41.9%	2557	32.3%
$50k-$100k	1945	23.6%	2910	36.2%
$100k-$150k	305	3.4%	861	11.7%
$150k+	147	1.8%	597	8.3%
Missing	458	6.0%	269	3.2%
Income (Household)				
<$20k	491	5.6%	293	3.4%
$20k-$50k	2082	25.3%	1365	16.4%
$50k-$100k	2705	35.4%	2857	35.9%
$100k-$150k	1167	15.6%	1626	21.3%
$150k+	819	10.9%	1344	19.1%
Missing	585	7.1%	357	3.9%
Homeownership				
Does Not Own Home	1214	14.6%	959	11.2%
Owns Home with Mortgage	2078	27.0%	2232	29.9%
Owns Home	4520	57.7%	4611	58.2%
Missing	37	0.7%	40	0.7%
Savings				
<$50k	1574	20.7%	1218	15.6%
$50k-$100k	1074	14.2%	864	11.3%
$100k-$1m	3329	42.4%	3827	48.6%
$1m+	613	8.3%	1094	15.2%

Table 1 Sample Characteristics by Sex (weighted)
(n= 15691)

	Female		Male	
	N	**%**	**N**	**%**
Missing	1259	14.4%	839	9.4%
Financial Security (Strict)				
Low	698	8.3%	446	5.1%
High	7151	91.8%	7396	94.9%
Financial Security (Moderate)				
Low	805	9.6%	519	6.0%
High	7044	90.4%	7323	94.0%
Financial Security (Inclusive)				
Low	1271	15.5%	782	9.3%
High	6578	84.5%	7060	90.7%
OAS as Highest Personal Income Source				
OAS	508	6.2%	188	2.2%
Non-Pensions (other)	7341	93.8%	7654	97.8%
OAS as Highest Household Income Source				
OAS	298	3.7%	163	1.9%
Non-Pensions (other)	7551	96.3%	7679	98.1%
Marital Status				
Single/Widowed/Divorced	3022	30.8%	1644	17.0%
Married/Living with Partner	4827	69.2%	6198	83.0%
Visible Minority Status				
Visible Minority	234	3.2%	304	4.1%
White	7615	96.8%	7538	95.9%
Retirement Status				
Completely Retired	4289	53.6%	3664	42.9%
Partially Retired	1002	13.1%	1447	18.6%
Not Retired	2558	33.3%	2731	38.5%
Province				

Table 1 Sample Characteristics by Sex (weighted)
(n= 15691)

	Female		Male	
	N	**%**	**N**	**%**
British Columbia	1565	29.5%	1607	30.5%
Alberta	753	9.0%	781	12.4%
Manitoba	867	8.8%	853	8.7%
Ontario	1725	13.3%	1748	15.6%
Quebec	1573	33.7%	1435	27.1%
Nova Scotia	801	3.5%	852	3.7%
Newfoundland	565	2.3%	566	2.1%
Highest Education				
Less than High School	496	6.8%	417	5.1%
High School Graduate	1430	18.5%	1191	14.4%
Diploma/ Certificate	2764	34.5%	2220	29.2%
Bachelor's Degree	1766	22.5%	1929	25.0%
Above Bachelor's Degree	1393	17.7%	2085	26.3%
Chronic Conditions				
None	339	5.1%	606	8.7%
At least one	7510	94.9%	7236	91.3%
Smoking Status				
Never Smoked	2648	33.6%	2040	27.2%
Former Smoker	4585	58.8%	5122	64.4%
Occasional Smoker	120	1.4%	124	1.6%
Current Daily Smoker	496	6.2%	556	6.9%
Alcohol Consumption				
Regular Drinker	5523	72.3%	6271	81.2%
Occasional Drinker	1213	13.7%	646	7.5%
Non-Drinker	1113	14.0%	925	11.4%

Note: N is not weighted

Weighted means of individual biomarkers used to develop the allostatic load index are presented in Table 2. All means for each biomarker were below the clinical high-risk cut-offs, with the exception of waist-to-hip ratio in males, which had a mean value of 0.979 while the clinical high-risk cut-off was 0.90.

Table 2 Allostatic Load Biomarker Characteristics (weighted)

	Female		Male	
Biomarker (Units)	**Mean**	**S.E.**	**Mean**	**S.E.**
Total Cholesterol (mmol/L)	5.55	0.014	4.90	0.014
High Density Lipoprotein (mmol/L)	1.69	0.007	1.33	0.005
Glycated Hemoglobin (blood %)	5.59	0.008	5.73	0.011
Waist-to-Hip Ratio	0.83	0.001	0.98	0.001
Systolic Blood Pressure (mmHg)	121.03	0.224	123.48	0.205
Diastolic Blood Pressure (mmHg)	72.45	0.126	77.00	0.129
Resting Heart Rate (bpm)	72.68	0.146	70.39	0.159
C-Reactive Protein (mg/L)	2.71	0.060	2.25	0.060
Albumin (g/L)	39.84	0.036	40.11	0.034

The distribution of high-risk designations according to both clinical and empirical cut-offs are presented in Table 3. Participants who were classified as clinically high-risk were those who fell either above or below the clinical high-risk cut-offs for each variable, as previously described. Clinical high-risk cut-offs were literature-based; empirical high-risk cut-offs were sample-based, defined by the 25th or 75th percentile of that biomarker. Low granularity of variables meant that the empirical high-risk group sometimes exceeded 25% of the sample when there were many tied values at the cut-off. Such was the case for albumin's empirical high-risk group, which included 27.98% of the sample (30.51% of women). Waist-to-hip ratio was the most prevalent clinical high-risk factor within the study population; 39.77% of women and 90.20% of men had values which exceeded the clinical high-risk cut-offs. This was the only biomarker in which the proportion of the sample considered high-risk decreased between clinical and empirical cut-off definitions due to the cut-off increasing in value between the two. In all other cases, empirical cut-offs were more inclusive than the clinical cut-offs in terms of high-risk classification.

Table 3 Allostatic Load High-Risk Designations and Distributions (weighted)

Clinical Allostatic Load (literature-based clinical high-risk cut-offs)

		% Clinically High-Risk		
	Clinical Cut-off	**Whole Sample**	**Female**	**Male**
Total Cholesterol (mmol/L)	**>6.208**	18.67	25.91	11.12
High Density Lipoprotein (mmol/L)	**<1.034**	14.88	5.79	24.36
Glycated Hemoglobin (blood %)	**>6.4**	8.42	5.89	11.07
Waist-to-Hip Ratio	**>0.85 (F) >0.9 (M)**	64.46	39.77	90.20
Systolic Blood Pressure (mmHg)	**>140**	13.26	12.60	13.95
Diastolic Blood Pressure (mmHg)	**>90**	6.47	3.89	9.16
Resting Heart Rate (bpm)	**>90**	6.74	6.81	6.65
C-Reactive Protein (mg/L)	**>3.0**	22.70	27.18	18.03
Albumin (g/L)	**<38.0**	16.23	17.98	14.41

Empirical Allostatic Load (sample-based empirical high-risk cut-offs)

		% Empirically High Risk		
	Empirical Cut-off	**Whole Sample**	**Female**	**Male**
Total Cholesterol (mmol/L)	**≥5.92**	26.60	35.65	17.18
High Density Lipoprotein (mmol/L)	**≤1.15**	24.83	11.93	38.28
Glycated Hemoglobin (blood %)	**≥5.80**	24.83	21.57	28.22
Waist-to-Hip Ratio	**≥0.8 8(F) ≥1.02 (M)**	24.30	23.03	25.63
Systolic Blood Pressure (mmHg)	**≥132.5**	22.99	21.52	24.51
Diastolic Blood Pressure (mmHg)	**≥81**	24.99	17.49	32.81
Resting Heart Rate (bpm)	**≥78.5**	25.07	26.81	23.22
C-Reactive Protein (mg/L)	**≥2.8**	24.96	29.49	20.24
Albumin (g/L)	**≤38.0**	27.98	30.51	25.35

Table 4 displays the mean values of both clinical and empirical allostatic load scores for both males and females above and below the age of 65, two groups which can loosely be described as pre- and post-OAS receipt. On average, males appeared to have higher allostatic load than females and mean allostatic load increased with age. Mean allostatic load scores displayed a clear gradient across both sexes and all age groups with respect to total personal income, total household income, homeownership, total savings, and education. By all financial security definitions, those classified as financially insecure had a greater mean allostatic load score than those who were not, as did those who reported OAS as highest personal income source.

Table 4 Mean Clinical and Empirical Allostatic Load Scores by age and sex (weighted)

	Clinical Allostatic Load (Literature-based cut-offs)				**Empirical Allostatic Load** (Sample-based cut-offs)			
	Female		**Male**		**Female**		**Male**	
	<65	**≥65**	**<65**	**≥65**	**<65**	**≥65**	**<65**	**≥65**
All	1.382	1.559	1.967	2.001	2.074	2.304	2.335	2.346
Income (Personal)								
<$20k	1.625	1.695	2.388	2.324	2.411	2.458	2.787	2.854
$20k-$50k	1.425	1.555	2.056	2.032	2.115	2.292	2.451	2.391
$50k-$100k	1.228	1.404	1.924	1.915	1.868	2.124	2.312	2.195
$100k-$150k	1.206	1.452	1.809	1.962	1.825	2.285	2.147	2.241
$150k+	0.986	1.468	1.788	1.822	1.613	2.122	2.005	2.100
Missing	1.174	1.494	1.988	1.945	1.873	2.273	2.469	2.472
Income (Household)								
<$20k	1.638	1.967	2.629	2.221	2.589	2.842	3.084	2.746
$20k-$50k	1.682	1.675	2.148	2.146	2.454	2.450	2.601	2.575
$50k-$100k	1.403	1.501	1.947	1.976	2.048	2.184	2.341	2.311
$100k-$150k	1.195	1.273	1.938	1.890	1.854	1.975	2.341	2.096
$150k+	1.169	1.305	1.827	1.867	1.801	2.004	2.131	2.141
Missing	1.191	1.490	1.993	2.060	1.969	2.329	2.522	2.639

Table 4 Mean Clinical and Empirical Allostatic Load Scores by age and sex (weighted)

	Clinical Allostatic Load (Literature-based cut-offs)				Empirical Allostatic Load (Sample-based cut-offs)			
	Female		Male		Female		Male	
	<65	≥65	<65	≥65	<65	≥65	<65	≥65
Homeownership								
Does Not Own Home	1.874	1.868	2.333	2.332	2.710	2.688	2.912	2.907
Owns Home with Mortgage	1.459	1.728	2.027	2.079	2.138	2.481	2.484	2.470
Owns Home Outright	1.208	1.441	1.851	1.918	1.874	2.168	2.118	2.208
Missing	1.394	0.917	2.288	1.838	1.983	1.447	2.628	1.988
Savings								
<$50k	1.740	1.884	2.221	2.208	2.607	2.691	2.789	2.697
$50k-$100k	1.434	1.590	2.033	2.067	2.101	2.249	2.468	2.515
$100k-$1m	1.271	1.439	1.922	1.924	1.912	2.158	2.238	2.236
$1m+	1.099	1.235	1.715	1.830	1.702	1.970	2.044	2.033
Missing	1.345	1.532	2.115	2.230	2.037	2.328	2.393	2.613
Financial Security (Strict)								
Financially Insecure	1.984	1.933	2.526	2.417	2.884	2.765	3.091	3.043
Financially Secure	1.336	1.517	1.939	1.976	2.013	2.252	2.297	2.305
Financial Security (Moderate)								
Financially Insecure	1.980	1.890	2.553	2.465	2.851	2.698	3.074	3.046
Financially Secure	1.329	1.514	1.932	1.968	2.006	2.251	2.291	2.297
Financial Security (Inclusive)								
Financially Insecure	1.849	1.928	2.394	2.423	2.725	2.711	2.857	2.969
Financially Secure	1.307	1.479	1.927	1.952	1.970	2.215	2.286	2.274
Highest Personal Income Source								
OAS	1.914†	1.719	3.031	2.411	2.527	2.525	3.344	2.906
Non-Pensions (other)	1.381	1.530	1.966	1.975	2.074	2.264	2.335	2.311
Highest Household Income Source								

Table 4 Mean Clinical and Empirical Allostatic Load Scores by age and sex (weighted)

	Clinical Allostatic Load (Literature-based cut-offs)				Empirical Allostatic Load (Sample-based cut-offs)			
	Female		Male		Female		Male	
	<65	≥65	<65	≥65	<65	≥65	<65	≥65
OAS	0.695†	1.727	2.412	2.330	1.367†	2.592	2.985	2.765
Non-Pensions (other)	1.383	1.543	1.967	1.984	2.076	2.276	2.335	2.324
Marital Status								
Single/Widowed/Divorced	1.563	1.711	2.097	2.229	2.317	2.499	2.575	2.711
Married/Living with Partner	1.313	1.475	1.940	1.956	1.981	2.196	2.285	2.274
Visible Minority Status								
Visible Minority	1.371	1.929	2.048	2.093	2.242	2.564	2.564	2.434
White	1.382	1.549	1.964	1.997	2.068	2.297	2.325	2.343
Retirement Status								
Completely Retired	1.424	1.561	1.968	2.013	2.138	2.318	2.317	2.364
Partially Retired	1.451	1.548	1.969	1.933	2.079	2.178	2.311	2.237
Not Retired	1.329	1.558	1.966	2.051	2.025	2.337	2.353	2.431
Province								
British Columbia	1.242	1.508	1.942	1.895	1.872	2.198	2.339	2.220
Alberta	1.226	1.332	1.742	2.018	1.873	1.979	2.025	2.246
Manitoba	1.563	1.687	2.305	2.249	2.362	2.555	2.662	2.660
Ontario	1.532	1.635	2.092	2.044	2.301	2.382	2.462	2.473
Quebec	1.443	1.586	1.916	1.998	2.155	2.366	2.285	2.340
Nova Scotia	1.496	1.551	1.941	1.994	2.161	2.327	2.349	2.399
Newfoundland	1.389	1.541	2.084	2.129	2.086	2.274	2.532	2.484
Highest Education								
Less than High School Grad	1.840	1.883	2.560	2.179	2.713	2.709	3.197	2.684
High School Grad	1.561	1.697	2.138	2.261	2.287	2.448	2.600	2.566
Diploma/ Certificate	1.441	1.602	2.070	2.066	2.169	2.323	2.485	2.546

Table 4 Mean Clinical and Empirical Allostatic Load Scores by age and sex (weighted)

	Clinical Allostatic Load (Literature-based cut-offs)				Empirical Allostatic Load (Sample-based cut-offs)			
	Female		Male		Female		Male	
	<65	≥65	<65	≥65	<65	≥65	<65	≥65
Bachelor's Degree	1.229	1.380	1.806	1.891	1.857	2.158	2.119	2.177
Above Bachelor's Degree	1.206	1.287	1.815	1.864	1.848	1.981	2.085	2.112
Chronic Conditions								
At least one	1.406	1.565	2.001	2.018	2.110	2.311	2.385	2.368
None	1.049	1.326	1.699	1.603	1.594	2.039	1.951	1.848
Smoking Status								
Never	1.307	1.488	1.855	1.844	2.043	2.230	2.180	2.171
Former Smoker	1.365	1.579	1.960	2.015	2.009	2.313	2.311	2.342
Occasional Smoker	1.336	1.550	2.175	2.156	2.113	2.263	2.579	2.727
Current Daily Smoker	1.860	1.856	2.368	2.568	2.724	2.762	3.016	3.224
Alcohol Consumption								
Regular Drinker	1.262	1.454	1.904	1.939	1.904	2.178	2.248	2.261
Occasional Drinker	1.796	1.852	2.328	2.375	2.678	2.614	2.778	2.848
Do not drink	1.644	1.753	2.176	2.195	2.435	2.577	2.666	2.629

† Indicates confidence interval for the estimated weighted mean crosses the null value.

Weighted mean values of allostatic load, when defined both clinically and empirically, followed clear socioeconomic gradients. These gradients were robust across the different definitions of allostatic load, and across all income-related variables and age groups as displayed in Figure 2 and Figure 3. This figure also highlights clear sex-based differences in average clinical allostatic load, which are less-defined for mean empirical allostatic load. These negative gradients observed in the means of both clinical and empirical allostatic load resemble income-related gradients seen for other health outcomes with respect to total household income, savings, and homeownership.

Figure 3. Mean Clinical Allostatic Load (weighted) by individual Income-Related Variables and overall Financial Security

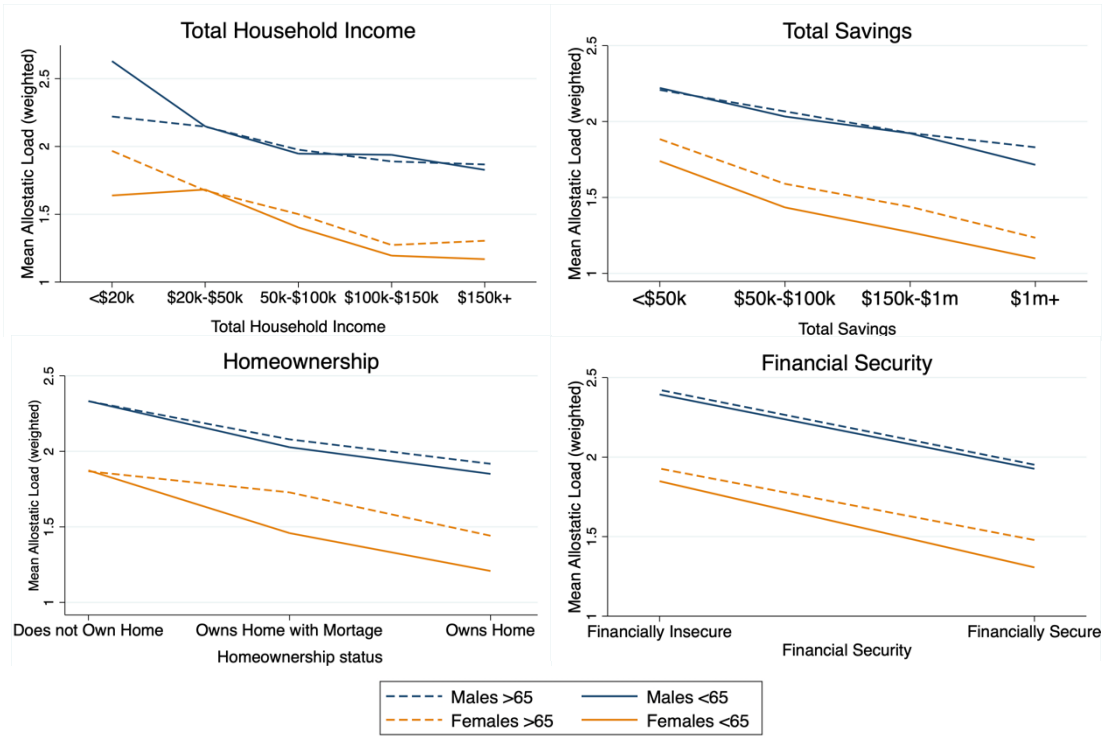
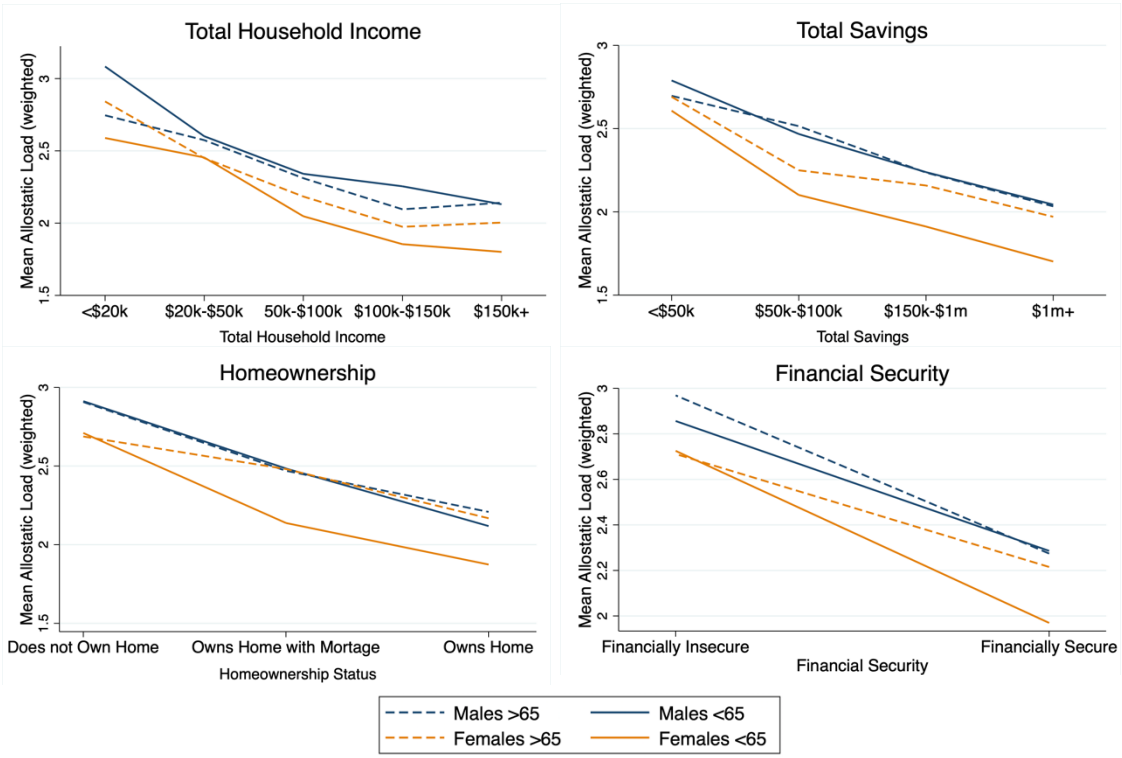


Figure 3. Mean Empirical Allostatic Load (weighted) by individual Income-Related Variables and overall Financial Security



5.2. Objective Two: Allostatic Load and Income-Related Variables

Weighted ordered logistic models were built to further assess the relationship between both allostatic load indices and important income-related variables. Odds ratios for ordered logistic models which are greater than 1.0 are interpreted as the likelihood of having a higher allostatic load score than a given reference allostatic load score, compared to a specified reference group. Similarly, odds ratios below 1.0 indicate the likelihood of a lower allostatic load score than a given reference score, compared to the reference group. For brevity throughout, this interpretation will be condensed to the likelihood of having a higher (or lower) allostatic load compared to the reference group. The results of selected multivariate analyses are presented and reported below; full regression outputs for all models can be found in Appendix 1.

Table 5 Clinical Allostatic Load's association with Total Household Income (weighted)

	Male			Female		
	Odds Ratio	**95% CI**		**Odds Ratio**	**95% CI**	
Total Household Income						
<$20k	1.635*	1.215	2.200	1.330*	1.044	1.694
$20k-$50k	1.174*	1.008	1.368	1.292*	1.103	1.512
$50k-$100k	1.004	0.890	1.132	1.181*	1.032	1.351
$100k-$150k	Ref			Ref		
$150k+	0.943	0.818	1.087	1.053	0.890	1.245
Missing	1.076	0.853	1.357	0.920	0.762	1.111

Multivariate model adjusted for age, age-squared (male only), marital status, minority status, retirement status, education level, province of residence, presence of chronic conditions, smoking and level of alcohol consumption.
* p-value < 0.05, considered statistically significant

Table 5 presents the fully adjusted, weighted ordered logistic regression results for clinical allostatic load and total household income. Here a clear gradient is observed, and those with lower household incomes were significantly more likely to have higher allostatic load. Females in the lowest income group (<$20k) were 1.330x more likely to report a higher allostatic load score (95% CI: 1.044, 1.694) compared to those reporting between $100k and $150k annually, while males were 1.635x more likely (95% CI: 1.215, 2.200). The second-lowest income group exhibited a weaker relationship than the

lowest income group for males (OR: 1.174, 95% CI: 1.008, 1.368) and females (OR: 1.292, 95% CI: 1.103, 1.512), although it remained statistically significant. The association dissipated completely for males before the reference group but remained for females in the third-lowest income group (OR: 1.181, 95% CI: 1.032, 1.315).

Table 6 Clinical Allostatic Load's association with Total Savings (weighted)

	Male			Female		
	Odds Ratio	95% CI		Odds Ratio	95% CI	
Total Savings						
<$50k	1.330*	1.156	1.532	1.515*	1.333	1.723
$50k-$100k	1.153*	1.001	1.330	1.170*	1.022	1.339
$100k-$1m	Ref			Ref		
$1m+	0.880	0.767	1.011	0.870	0.743	1.018
Missing	1.220*	1.053	1.413	1.010	0.891	1.144

Multivariate model adjusted for age, age-squared (male only), marital status, minority status, retirement status, education level, province of residence, presence of chronic conditions, smoking and level of alcohol consumption.
* p-value < 0.05, considered statistically significant

A similar relationship was observed between clinical allostatic load and total savings (Table 6). Lower total savings were associated an increased allostatic load for the two lowest groups, an association which attenuated, but did not dissipate, towards the reference group. Females in the lowest savings group (<$50k) were 1.515x more likely to have a higher allostatic load (95% CI: 1.333, 1.723), while males were 1.330x more likely to have higher allostatic load (95% CI: 1.156, 1.532), compared to the reference group ($100k – $1m). In the second-lowest savings group, females (OR: 1.170, 95% CI: 1.022, 1.339) and males (OR: 1.153, 95% CI: 1.001, 1.330) both exhibited weaker but statistically significant associations with higher allostatic load.

A slightly weaker relationship was observed between empirical allostatic load and total personal income (Table 7). Those in the lowest income group (<$20k) had a significantly increased likelihood of having higher allostatic load, though that association dissipated for males outside of that group and continued no further than the second-lowest income group for females. The associations were relatively small: males in the lowest income group were 1.281x more likely to have a higher allostatic load (95% CI: 1.062, 1.544),

while females were 1.295x more likely (95% CI: 1.128, 1.487), compared to the reference group ($50k – $100k). While statistically significant, the relationship for females in the second-lowest income group attenuated considerably (OR: 1.158, 95% CI: 1.034, 1.296).

Table 7 Empirical Allostatic Load's association with Total Personal Income (weighted)

	Male			Female		
	Odds Ratio	95% CI		Odds Ratio	95% CI	
Total Personal Income						
<$20k	1.281*	1.062	1.544	1.295*	1.128	1.487
$20k-$50k	1.110	0.999	1.232	1.158*	1.034	1.296
$50k-$100k	Ref			Ref		
$100k-$150k	0.973	0.843	1.123	1.071	0.840	1.365
$150k+	0.861	0.724	1.024	0.956	0.714	1.281
Missing	1.194	0.949	1.503	0.958	0.795	1.154

Multivariate model adjusted for age, age-squared (male only), marital status, minority status, retirement status, education level, province of residence, presence of chronic conditions, smoking and level of alcohol consumption.
* p-value < 0.05, considered statistically significant

Table 8 Empirical Allostatic Load's association with Homeownership (weighted)

	Male			Female		
	Odds Ratio	95% CI		Odds Ratio	95% CI	
Homeownership						
Does Not Own Home	1.697*	1.468	1.963	1.614*	1.404	1.856
Owns Home with Mortgage	1.388*	1.255	1.535	1.369*	1.234	1.518
Owns Home Outright	Ref			Ref		
Missing	1.418	0.809	2.485	0.852	0.450	1.610

Multivariate model adjusted for age, age-squared (male only), marital status, minority status, retirement status, education level, province of residence, presence of chronic conditions, smoking and level of alcohol consumption.
* p-value < 0.05, considered statistically significant

A strong relationship was observed between empirical allostatic load and homeownership status (Table 8). Those who did not own a home, or owned it with a mortgage, were both

significantly more likely to have higher allostatic load compared to those who owned their home outright. Although the association did attenuate as some level of homeownership was obtained, the relationship between homeownership and allostatic load was quite strong and consistent between males and females. Females and males who did not own their home were 1.614x (95% CI: 1.404, 1.856) and 1.697x (95% CI: 1.468, 1.963) more likely to have a higher allostatic load compared to those who did. Those who owned a home with a mortgage were also more likely to have a higher allostatic load (OR_{male}: 1.388, 95% CI: 1.255, 1.535; OR_{female}: 1.369, 95% CI: 1.234, 1.518). Not owning a home had the largest association of all the presented income-related variables with higher allostatic load, and this strong relationship held across clinical allostatic load as well.

All income-related variables were significantly associated with allostatic load, although the relationship exhibited varied in size. The strongest associations with allostatic load were seen for total household income, total savings, and homeownership status; for all these variables, the lowest category (i.e., those with less) had the strongest relationship with increased allostatic load, and this relationship tended to attenuate towards their

Table 9 Clinical Allostatic Load's association with Financial Security (weighted)

	Male			Female		
	Odds Ratio	**95% CI**		**Odds Ratio**	**95% CI**	
Financial Security (Strict)						
Financially Insecure	1.610*	1.300	1.994	1.483*	1.250	1.759
Financially Secure	Ref			Ref		
Financial Security (Moderate)						
Financially Insecure	1.725*	1.408	2.114	1.371*	1.163	1.616
Financially Secure	Ref			Ref		
Financial Security (Inclusive)						
Financially Insecure	1.512*	1.279	1.787	1.471*	1.287	1.681
Financially Secure	Ref			Ref		

Multivariate model adjusted for age, age-squared (male only), marital status, minority status, retirement status, education level, province of residence, presence of chronic conditions, smoking and level of alcohol consumption.
* p-value < 0.05, considered statistically significant

relative reference groups. Gradients existed for both empirical and allostatic load and were consistent across all income-related variables and both sexes.

Total household income, total savings and homeownership status were combined to create the financial security indices (Table 9). Each level of the variable used to classify participants into a financially insecure group was significantly associated with increased allostatic load in earlier models. Across all three definitions, those classified as financially insecure were significantly more likely to have a higher allostatic load compared to those who were financially secure. In the most inclusive financial security index, financially insecure males and females were 1.512x (95% CI: 1.279, 1.787) and 1.471x (95% CI: 1.287, 1.681) more likely to have a higher clinical allostatic load compared to financially secure individuals. This pattern and coefficient magnitude was consistent across all three financial security definitions, with these associations being at least as strong as the strongest associations observed between individual income-related variables and allostatic load. A similar pattern was exhibited for empirical allostatic load (results not shown). All odds ratios were similar by way of interpretation, so the most inclusive financially insecure group (i.e., the one with the largest sample size) was selected for future models.

All the above regressions were adjusted for age, age-squared (male only), marital status, minority status, retirement status, education level, province of residence, presence of chronic conditions, smoking and level of alcohol consumption. The only covariate which was not statistically significant in all models was retirement status; this remained in the model for discussion purposes due to its assumed close relationship to Old Age Security and older adults in general. All other covariates were statistically significant in at least some models, with education and smoking having two of the strongest associations between the controls and allostatic load. Full regression outputs for all models can be found in Appendix 1.

5.3. Objective Three: Old Age Security and Allostatic Load

Results addressing objective two established a clear relationship between allostatic load, income-related variables and financial security. Further ordered logistic analyses were

then conducted to investigate whether receiving Old Age Security as highest personal income source modified the relationship between financial security and allostatic load. Interacting the financial security variable with the dummy variable OAS as highest personal income source allowed for further investigation of those individual variable's relationship with allostatic load, along with the combined association of both these variables on allostatic load.

Table 10 presents the fully adjusted regression results for clinical allostatic load and financial security, OAS as highest personal income source, and their interaction term. In this model, financially insecure males (OR: 1.569, 95% CI: 1.316, 1.871) and females (OR: 1.544, 95% CI: 1.335, 1.785) remained significantly more likely to have a higher clinical allostatic load than financially secure participants. Additionally, males who reported OAS as highest personal income source were 2.12x more likely to have a higher clinical allostatic load score than those who did not (95% CI: 1.476, 3.045). No statistically significant association was seen here for females who reported OAS as highest personal income source.

Table 10 Clinical Allostatic Load, Financial Security and Old Age Security (weighted)

	Male			Female		
	Odds Ratio	**95% CI**		**Odds Ratio**	**95% CI**	
Financial Security (Inclusive)						
Financially Insecure	1.569*	1.316	1.871	1.544*	1.335	1.785
Financially Secure	Ref			Ref		
Highest Personal Income Source						
OAS	2.12*	1.476	3.045	1.175	0.943	1.464
Other	Ref			Ref		
Interaction Term						
Financially Insecure•OAS	0.398*	0.227	0.696	0.677*	0.483	0.949
Other	Ref			Ref		

Multivariate model adjusted for age, age-squared (male only), marital status, minority status, retirement status, education level, province of residence, presence of chronic conditions, smoking and level of alcohol consumption.
* p-value < 0.05, considered statistically significant

The interaction term between financial security and OAS as highest personal income source was statistically significant for both males and females, with the coefficient in the opposite direction from the individual associations. When OAS was their highest source of personal income, financially insecure males were significantly more likely to have a lower clinical allostatic load (OR: 0.398, 95% CI: 0.227, 0.696) compared to other financially insecure males. A similar but slightly weaker association was exhibited for females (OR: 0.677, 95% CI: 0.483, 0.949). These results show the association between financial insecurity and clinical allostatic load was almost completely negated by receiving OAS as highest personal income source in both males and females.

The association of OAS as highest personal income source and clinical allostatic load in financially insecure females and males is presented visually in Figure 4. The fitted marginal probabilities of each allostatic load score are graphed for financially insecure older adults who are receiving OAS as highest personal income source (orange), and those who are not (grey). Amongst financially insecure older adults, OAS as highest personal income source was associated with an increased probability of a lower clinical allostatic load score and decreased probability of a higher allostatic load score (i.e., those in the OAS group were more likely to be healthy).

Figure 4. Fitted Marginal Probabilities for Clinical Allostatic Load scores amongst Financially Insecure Older Adults by OAS as Highest Personal Income Source

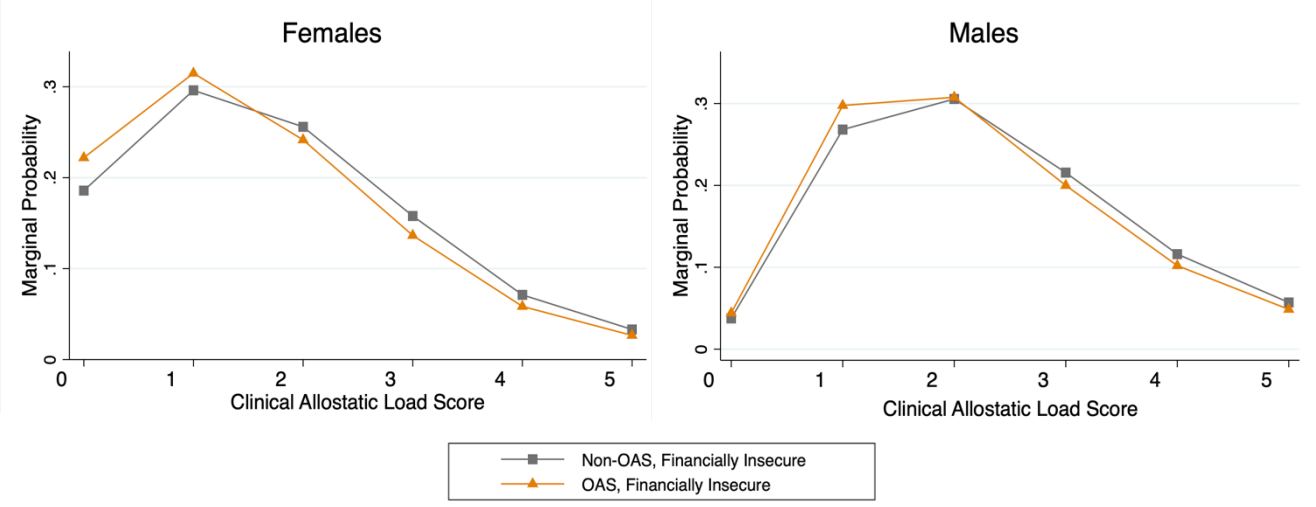


Table 11 presents the fully adjusted regression results for empirical allostatic load and financial security, the OAS indicator, and their interaction term. Financially insecure males (OR: 1.436, 95% CI: 1.212, 1.701) and females (OR: 1.571, 95% CI: 1.365, 1.807) were both significantly more likely to have a higher empirical allostatic load than those who were financially secure, and males who reported OAS as highest personal income source had 1.919x the likelihood of having a higher empirical allostatic load (95% CI: 1.314, 2.802) than those who did not. Once again, no statistically significant association was seen here for females.

Table 11 Empirical Allostatic Load, Financial Security and Old Age Security (weighted)

	Male			Female		
	Odds Ratio	**95% CI**		**Odds Ratio**	**95% CI**	
Financial Security (Inclusive)						
Financially Insecure	1.436*	1.212	1.701	1.571*	1.365	1.807
Financially Secure	Ref			Ref		
Highest Personal Income Source						
OAS	1.919*	1.314	2.802	1.162	0.930	1.452
Other	Ref			Ref		
Interaction Term						
Financially Insecure•OAS	0.441*	0.246	0.790	0.637*	0.450	0.901
Other	Ref			Ref		

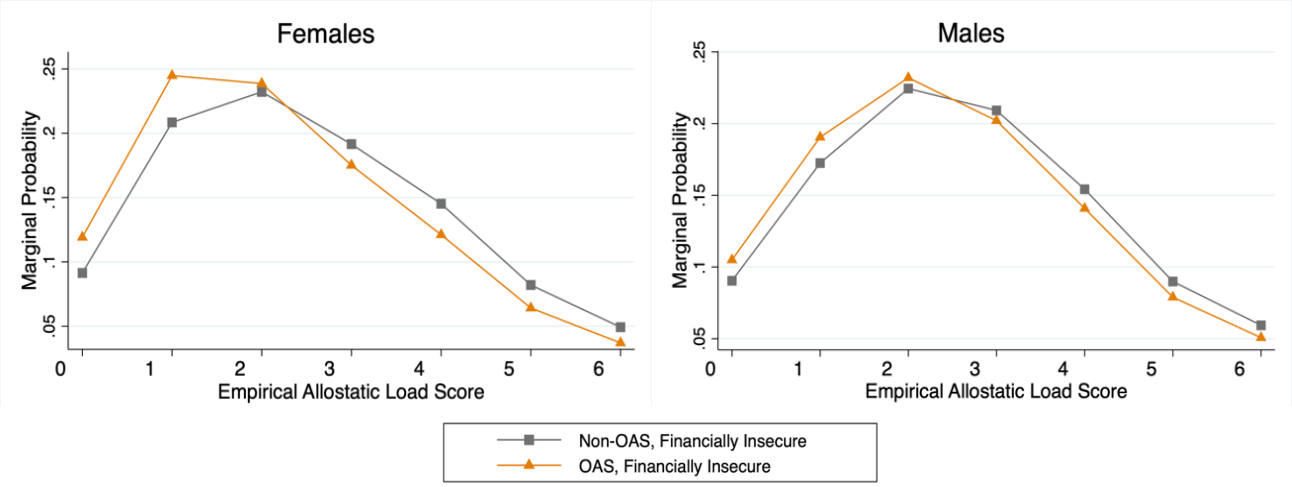
Multivariate model adjusted for age, age-squared (male only), marital status, minority status, retirement status, education level, province of residence, presence of chronic conditions, smoking and level of alcohol consumption.
* p-value < 0.05, considered statistically significant

The interaction term was statistically significant for both males and females, reversing the direction of the association seen between each variable individually. When financially insecure older adults received OAS as highest personal income source, males (OR: 0.441, 95% CI: 0.246, 0.790) and females (OR: 0.637, 95% CI: 0.450, 0.901) were significantly more likely to have a lower empirical allostatic load relative to those who did not. For males, this association almost completely negated the association between financial insecurity and allostatic load; for females, the association was slightly more modest.

Figure 5 plots the fitted marginal probabilities for both financial insecurity groups of having each empirical allostatic load score, and the pattern observed is consistent with

Figure 4. When financially insecure older adults receive OAS as highest personal income source (orange), they are more likely to have a lower empirical allostatic load (and less likely to have a higher empirical allostatic load) compared to other financially insecure older adults (grey). This association is consistent for both males and females.

Figure 5. Fitted Marginal Probabilities for Empirical Allostatic Load scores amongst Financially Insecure Older Adults by OAS as Highest Personal Income Source



5.4. Objective Four: Changes in Allostatic Load beyond the mean

Unconditional quantile regressions built on these results by modelling changes in allostatic load that the mean may not otherwise adequately describe. The same models specified in Tables 10 and 11 were used for this analysis, and the estimated interaction coefficients (with 95% confidence intervals) across the unconditional (i.e., marginal) distribution of allostatic load are displayed visually in the figures below.

Figure 6 presents the estimated coefficients for clinical allostatic load across its distribution in financially insecure adults who report OAS as highest personal income source, relative to those who do not. For both males and females, the trend is similar: OAS is more strongly associated with a lower clinical allostatic in those with the highest allostatic load (i.e., in the worst-off). For females, estimated coefficients become statistically significant above the 8th decile of allostatic load (β=-0.24, 95% CI: -0.43, -0.05), but males see statistically significant improvements in allostatic load above the 4th decile (β=-0.24, 95% CI: -0.45, -0.04) and further improvements above the 7th decile (β=-

0.72, 95% CI: -1.12, -0.32) of allostatic load. OAS as highest personal income source was therefore associated with an improvement in allostatic load in males at the 7th decile from a score of 3, to a score of around 2.3. The worst-off financially insecure older adults, therefore, were significantly more likely to have lower clinical allostatic load when they were receiving OAS as highest personal income source, relative to financially insecure older adults who were not.

Figure 6. Unconditional Quantile Regression Coefficient Plot for Clinical Allostatic Load

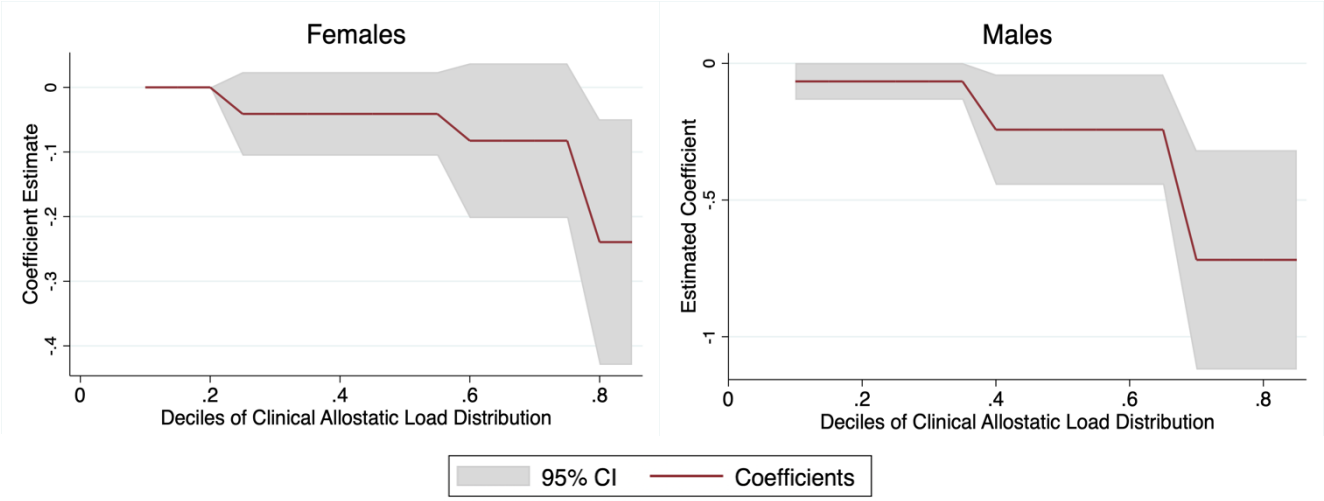
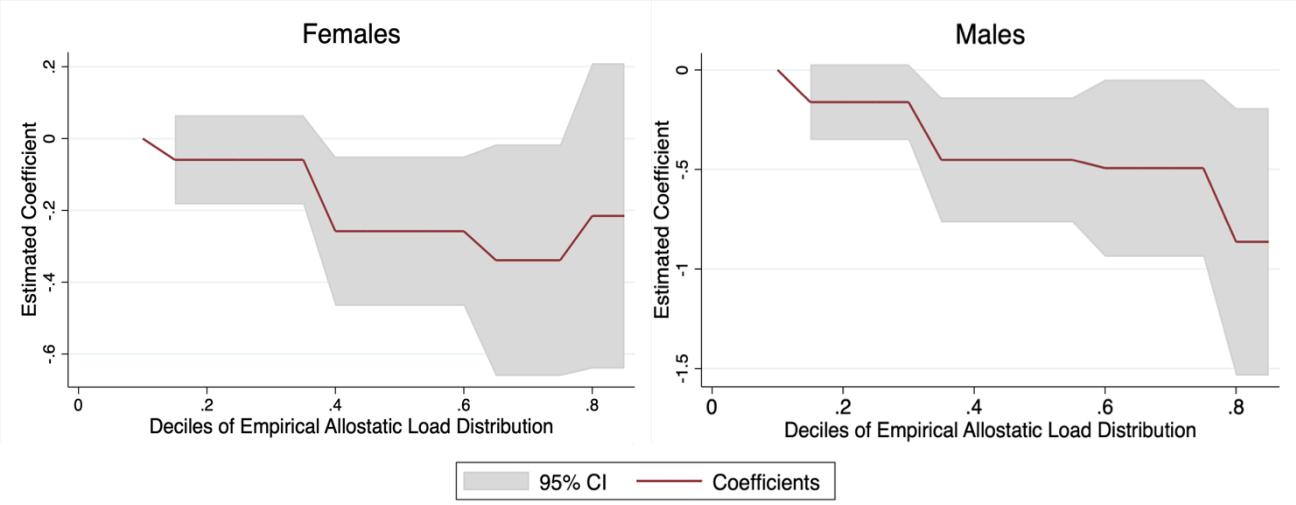


Figure 7 presents the change in empirical allostatic load across its distribution for the same financially insecure, OAS group. Similar trends are exhibited for empirical allostatic load as for clinical allostatic load; OAS is more strongly associated with improved empirical allostatic load in individuals in the highest deciles of empirical allostatic load. For females, estimated coefficients are statistically significant from the 4th decile of allostatic load and persisted in magnitude despite losing significance in the highest deciles. For males however, estimated coefficients are statistically significant past the 3rd decile and continue in to increase in magnitude across the rest of the distribution of allostatic load, increasing in magnitude up to the 8th decile (β=-0.86, 95% CI: -1.53, -0.19). For financially insecure males with allostatic load above the 8th decile, OAS as highest personal income source was associated with an improvement in empirical allostatic from a score of 4 to a score of approximately 3.1. Once more, the worst-off financially insecure older adults receiving OAS as highest personal income source were

more likely to have a lower empirical allostatic load, relative to financially insecure older adults who were not.

Figure 7. Unconditional Quantile Regression Coefficient Plot for Empirical Allostatic Load



Fundamentally, the highest allostatic load deciles were not as high in financially insecure older adults receiving OAS as highest personal income source, meaning OAS was associated with a narrowing of the allostatic load distribution. The overall patterns proved relatively consistent for both males and females across both empirical and clinical definitions of allostatic load.

5.5. Sensitivity Analyses

5.5.1. Medication Use

Following the analysis, each model was reproduced using a clinical and empirical allostatic load index adjusted for participant's medication use as the outcome variable. The adjusted allostatic load indices considered two conditions for which participants were taking medication: hypertension and diabetes and adjusted three biomarkers based on this information: SBP, DBP, and glycated hemoglobin. This sensitivity analysis did not reveal any differences within the summary statistics or between any of the regression models, and all trends and interpretations remained consistent.

5.5.2. Chronic Conditions

A sensitivity analysis also replicated all models and did not include chronic conditions in the model. All coefficient estimates remained virtually unchanged, and interpretations remained identical. A comparison of the regression output for objective three between confounder and collider approaches can be found in Appendix 1.

CHAPTER 6 DISCUSSION

6.1. Overview

The overall goal of this study was to investigate the objective health benefits of receiving guaranteed annual income in Canada. To do this, I explored the relationships that exist between various income-related variables, overall financial security, and allostatic load, along with how these relationships change when one begins to receive GAI. The GAI assessed in this study was Old Age Security, a public pension provided automatically to virtually all Canadians upon turning 65. The findings of this study show allostatic load is patterned by sociodemographic characteristics and income-related variables, including financial security, and that lower levels of income, savings, homeownership, and overall financial security (a composite variable of all three income-related variables) are associated with higher allostatic load. Allostatic load, both clinical and empirical, was more likely to be lower in financially insecure older adults who receive OAS as highest personal income source. This improvement was shown to be largest among financially insecure individuals with the highest allostatic load scores, suggesting OAS may narrow the distribution of both clinical and empirical allostatic load by reducing allostatic load the most in those who are the worst-off. These results confirm existing knowledge about the patterns of allostatic load and general health across income-related variables, provide evidence of the objective health benefits a guaranteed annual income could provide, and may have important implications for future health and public policy.

6.2. Allostatic Load and Income-Related Variables

Both clinical and empirical allostatic load were significantly associated with all income-related variables used (total personal income, total household income, total savings, and homeownership). Low levels of personal and household income, low savings, and not owning a home were all associated with higher allostatic load scores, as were all three definitions of low financial security. Strong associations were seen at the low levels of the income-related variables, but clinical and empirical allostatic load continued to follow relatively consistent gradients across all levels of income-related variables. These gradients are consistent with previous research which has associated low socioeconomic

and financial status with higher allostatic load[7,14,15,97] along with broader health research which has associated low income, wealth and low socioeconomic status with increased morbidity and mortality,[2,13,20,23,24] among other conditions. Additionally, gradients in allostatic load across all income-related variables lend credence to the relative income hypothesis,[40] which discusses how one's relative economic position, not just their absolute income, may be also relevant to health. As these results show, income-related variables appear to have at least some association with health and health outcomes across their whole distribution, not solely in lower levels and in those considered the worst off.[15]

Not owning a home was particularly strongly associated with having a higher empirical and clinical allostatic load in males ([OR_E: 1.498, 95% CI: 1.468,1.963], [OR_C: 1.697, 95% CI: 1.286,1.745]) and females ([OR_E: 1.614, 95%CI: 1.369,1.828], [OR_C: 1.582, 95%CI: 1.404,1.856]). This is consistent with existing research on this relationship, which has found lack of homeownership to attenuate the socioeconomic status-allostatic load association by 78%,[35] and be associated with elevated C-reactive protein,[34] worse self-rated health,[27,32,33] and increased all-cause mortality.[36] Low savings were also associated with higher clinical and empirical allostatic load in both males and females, having previously been shown to be associated with worse self-rated health,[37–39] and increased mortality.[37] While low total personal income was significantly associated with higher clinical and empirical allostatic load, the magnitude of these associations were, in general, the weakest relative to all other income-related variables.

Personal income was not expected to be a totally adequate measure of overall financial stability in older adults. Such a situation is known to occur when income and overall wealth are decoupled from each other, a paradox somewhat unique to this age group. With decreased labour force participation around retirement, income tends to decrease while other measures of wealth (i.e., homeownership and savings) become more relevant.[23–25] These non-income measures of wealth buffer against income decreases, general financial stress, and the possibility of sudden financial shock,[24] and thus act to protect against stressors which can lead to higher allostatic load.[97] This offers an explanation as to why having less non-monetary assets (such as not owning a home) was strongly associated with higher allostatic load in this study, while low personal income was less important than one might have assumed.

Financial security, a composite variable which combined the three most relevant income-related variables (total household income, total savings, homeownership) was also significantly associated with a higher clinical and empirical allostatic load. Financial security's association with allostatic load was also larger than that of total personal or household income alone. This suggests allostatic load may indeed be more related to the general availability of financial resources, not just one's income alone. The financial security composite variable may more accurately capture chronic financial struggles; while absolute income may be prone to acute fluctuation in older adults, homeownership and savings are more stable over time. Furthermore, those with (or without) these assets are more likely to have been that way for some time. Because of this, overall financial security is more consistent with the fundamental premise of allostatic load and how it acts to influence physiological dysregulation: chronic exposure to environmental stressors over time.[15,121,130] Not owning one's home, having minimal savings, and having low income all represent stressors which, over time, may impose a biological toll on individuals. As the results show, these individuals were more likely to have higher allostatic load, representing the physiological manifestation of the pressures and stressors that come with having low financial security.

These results are particularly important given the clinical implications of having high allostatic load (and by extension, low financial security). Elevated allostatic load is predictive of poor health outcomes, including cardiovascular diseases and all-cause mortality.[15,97] Previous research has indicated a one-point increase in allostatic load increases the odds of being frail by 16%[102] and mortality rates by as much as 40%.[100] Weighted mean differences of close to a point were seen between the highest and lowest groups of some of the income-related variables. For example, males under 65 in the lowest total household income group (<$20k) had a mean allostatic load 0.802 points below the highest group ($150k+), and females under 65 in the lowest savings group (<$50k) had a mean allostatic load 0.641 points below the highest group ($1m+). Additionally, the significantly higher likelihood of higher allostatic load in financially insecure older adults could, by extension, also increase the likelihood of more serious conditions such as frailty,[102,103,108] cardiovascular diseases,[15,93,97] and all-cause mortality.[15,93,100,101] Operationalizing these results shows the considerable impact low

financial security may have on comparative health outcomes, and the means through which low-income Canadians are more likely become high-cost healthcare users.[20]

6.3. Allostatic Load and Old Age Security

Receiving OAS as highest personal income source was shown to modify the association between financial security and both clinical and empirical allostatic load. The associations found between OAS, a guaranteed annual income, and improved allostatic load are critically important findings for this study. For both financially insecure males and females, those receiving OAS as highest personal income source were significantly more likely to have a lower allostatic load, with this observed association being stronger in males than females. For males, the interaction term (OR: 0.398, 95% CI: 0.227,0.696) was of similar magnitude (but opposite direction) to financial insecurity alone (OR: 1.569, 95% CI: 1.316,1.871). This suggests the combined impact of OAS as highest personal income source in financially insecure males may effectively remove the association between financial insecurity and clinical allostatic load (and attenuate this association in females). This is likely the result of the stability that OAS provides vulnerable older adults through its guaranteed nature and displays the potential GAI programs may hold in terms of reducing income-related health inequalities.

Reducing health gaps and narrowing health divisions between the worst and best-off socioeconomic groups has been identified as a key goal of social policies which aim to reduce income-related inequities and inequalities.[60,63] Additionally, policies that may not explicitly target population health outcomes can still have (inadvertent) benefits to population health. OAS is primarily an economic intervention, but when financially insecure older adults received it as their highest personal income source, it is associated with improved allostatic load. By countering the relationship between financial insecurity and increased allostatic load, OAS as highest personal income source acted to make financially insecure older adults more similar to those who are financially secure. The measurable health improvement that OAS was associated with in vulnerable populations, despite pre-existing poorer health, is an important finding which displays the potential GAI may hold in terms of narrowing health inequalities. Such improvements are

consistent with previous improvements seen in self-rated health and food security as a result of OAS[3,79,80,127] and other GAI programs and experiments.[71,74]

OAS significantly modified the financial insecurity-allostatic load association when it was the participant's highest personal income source. The health benefits from receiving OAS may therefore relate less to its absolute dollar value and more to its relative value; OAS was associated with an individual's allostatic load when it makes a substantial difference to that individual. $19,410.36[77] is not a high annual salary, particularly for well-off older adults. Yet for those who are financially insecure, it is likely very substantial and represents a large increase from provincial-level social assistance (Nova Scotia's social assistance program provides, at most, $8,232 per year).[78] The diminishing returns of increased income on life expectancy are well documented,[12] and these findings suggest the similar principles are in force regarding allostatic load. For well-off older adults, OAS appeared relatively inconsequential (particularly as it begins to be clawed back for incomes over $79,054 and stops altogether above $133,527[77]). However, OAS may be very important for financially insecure individuals, particularly when it becomes their highest source of personal income. Because of the stability and opportunity it affords, OAS as highest source of personal income was shown to significantly increase financially insecure older adult's likelihood of having a lower allostatic load (and potentially the associated poor health outcomes), compared with other financially insecure older adults not receiving such meaningful benefits.

6.4. OAS and Allostatic Load Beyond the Mean

The final objective for this study was examining the association of OAS as highest personal income source and allostatic load among financially insecure older adults across the population distribution of allostatic load. Unconditional quantile regression analysis showed that improvements in both clinical and empirical allostatic load for financially insecure older adults were generally greater for those at the higher end of the allostatic load distribution. These results speak to the population impact of OAS and show how it acted to narrow the distribution of allostatic load scores. Specifically, this means that among the financially insecure, the highest allostatic load scores (i.e., the scores of most concern) were lower when receiving OAS as highest personal income source.

This relationship held true for both sexes and allostatic load definitions, but particularly so for males, who tend to exhibit higher allostatic load scores in general.[15] The strongest associations between OAS and improved allostatic load were seen for financially insecure males with clinical allostatic load above the 70th percentile, and empirical allostatic load above the 80th percentile. For these individuals, this association amounted to a clinical allostatic load 0.7 allostatic load units lower than similar financially insecure older adults not receiving OAS, and an empirical allostatic load 0.9 allostatic load units lower. Such improvements in allostatic load are of an equivalent magnitude to the difference between having less than $50k in savings and having more than $1m in savings, or between not owning a home and owning a home outright. Importantly, these substantial health improvements associated with OAS were seen in those who had the worst allostatic load. This is significant for knowledge surrounding the design of population health interventions, especially when considering that universal interventions have been thought to inadvertently increase inequalities in health.[131] The work of Graham[63] and Benach,[60] however, describe how population-wide policies can still act to narrow income-related health inqualities when they have their largest benefits on those who need it the most. Here OAS, a near-universal policy, is seen to have its largest benefits on those who are the worst-off, and as a result, act to narrow of the population distribution of allostatic load. This finding encourages the idea that relatively straight-forward GAI programs can be used as effective population health interventions to lessen income-related health inequalities and improve the health of vulnerable populations.

6.5. Emergent Observations regarding Allostatic Load

Allostatic load displayed consistent gradients and associations between all levels of income-related variables, including financial security and Old Age Security. Lower levels of financial resources were associated with higher allostatic load, and OAS modified this relationship and was associated with improved allostatic load. Importantly, these gradients were robust to two fundamentally different definitions of allostatic load which were examined side-by-side. Clinical and empirical allostatic load displayed consistencies in all associations despite, in some cases, large absolute differences in the high-risk cut-points used. Statistics Canada's seminal results also used this approach and defined allostatic load both ways, but similarly found minimal differences between

them.[15] Clinical high-risk cut-offs incorporate biological measurements of what is considered unhealthy or at higher risk for certain poor health outcomes. Despite their fundamental basis in medical literature, similar results and patterns were still observed when the somewhat cruder approach of sample-based empirical cut-offs was used. In the case of waist-to-hip ratio, over 90% of males were clinically high-risk compared to the 25.6% of males who fell into the empirically high-risk group. For other variables, empirical cut-offs tended to be much more inclusive than clinical cut-offs; for glycated hemoglobin, 8.4% of the sample were clinically high-risk while 24.8% of the sample were empirically high-risk. This inclusiveness meant that empirical allostatic load scores tended to be higher than clinical scores. However, despite the variation in cut-offs and distribution of scores, financial gradients and associations remained similar across the full analysis for both definitions. Sample-based and clinically-based high-risk classifications were both patterned by financial security and associated with improvements in financially insecure groups receiving OAS. While clinical derivations may hold more weight in terms of perceived validity and scientific rigour, the consistency between clinical and empirical definitions shows there is merit to using relative measures such as empirical allostatic load to supplement existing clinical knowledge.

The distribution of high-risk classifications used to construct allostatic load indices allowed for an interesting assessment of the health profile of older Canadian adults. For example, the clinical high-risk cut-off for glycated hemoglobin is the same cut-point used for the diagnosis of diabetes,[114] and the 8.4% of high-risk older adults in the sample is almost identical to current population rates, which estimate 8.8% Canadians currently live with diabetes.[132] The 64.5% of the sample with a clinically high-risk waist-to-hip ratio somewhat aligns with the combined population rates of overweight or obese older adults in Canada as measured through BMI.[133] However, the 90.2% of clinically high-risk males is much higher than the Statistics Canada-reported overweight and obesity rates for males over 65 in Canada.[133] This, perhaps, is a comment on the study population itself. Income and wealth have been positively associated with obesity prevalence amongst males, but negatively associated with obesity prevalence amongst women.[134] Characteristics of this sample are consistent with reviews of the CLSA[135] which have indicated that participants appear to be wealthier than the general population. This income-obesity relationship,[134]

therefore, could explain how 90.20% of males were classified as clinically high-risk for waist-to-hip ratio, while only 39.77% of females received such classification, despite sex-based clinical high-risk cut-offs likely designed to adjust for biological differences. Considering previous research has shown waist-to-hip ratio to be a better predictor of poor health outcomes than BMI,[115] this may provide some cause for concern for older male adults in Canada.

Sex was an ongoing consideration throughout the analysis. Associations between income-related variables, financial security, allostatic load, and OAS were similar across both sexes, but were often smaller in magnitude for females than for males. This is quite likely the result of a complex web of social, economic, and biological factors, including males tending to have higher allostatic load in general[15] and having more theoretical room for improvement. Another possibility could be the way allostatic load was defined. As discussed above, both allostatic load indices were developed using pooled cut-points for males and females, with the exception of waist-to-hip ratio. It has been noted previously that sex-dependent differences in allostatic load (and in particular, its association with age) are sensitive to how high-risk thresholds are defined,[15] so sex-specific cut-offs may improve the construct validity of allostatic load. This would, however, require further research around the sex-based biological differences in the biomarkers used, differences which are not altogether clear given the lack of sex-specific clinical cut-offs in the literature currently. As a result, the cut-offs used in this study are based on the best information that was available, and consideration to sex-specific cut-offs was deemed outside the scope of this project.

Previous research has also documented a leveling-out of allostatic load scores around the age of retirement for males, while females continue to exhibit a consistent increase into their senior years.[15] An age-squared interaction term was used to control for the non-linear relationship in males but was not included in female models due to statistical insignificance and having no major role in model interpretation. The differences in estimates and allostatic load between males and females could relate to the age of this cohort and employment climates over the past half-century. If females were less involved in the labour force than they are today, this may have implications on allostatic load and its relationship financial security across the life course for those in the sample. A

gendered aspect to these findings, therefore, may explain some of the differences observed in this study, and these findings may not be generalizable to more current cohorts for this reason.

Further relevant to this discussion is retirement status, which was not shown to have a relationship with allostatic load and remained in the model solely for discussion purposes. While gender is once again an important consideration given retirement status's close relationship with labour market participation, being fully retired was not significantly associated with allostatic load in either males or females, consistent with the notion that the health impacts of retirement appear relatively complex. Some studies have found positive associations between health and retirement,[136] particularly in Europe where it has been shown to lead to a 35% decrease in the probability of reporting fair, bad or very bad health.[137] However, two Canadian studies found no statistically significant relationships to exist between retirement and self-reported mental and physical health.[138,139] Evidence also suggests that unhealthy individuals are more likely to retire both earlier and in general,[140,141] further muddying the effects of retirement and health improvements. Despite controlling for retirement status in all models in this analysis, it's association with allostatic load remained largely lacked statistical significance throughout.

6.6. Implications of Competing Financial Security Composite Variables

Three financial security variables were constructed based on various, logical cut-points within three income-related variables (total household income, total savings, homeownership). The goal of this composite variable was to obtain an improved overall understanding of the financial resources available to participants and model the associations between income-related variables and allostatic load in older adults beyond income alone. It also served to account for the low-income-high-wealth paradox, whereby income decreases with retirement and becomes a less-relevant measure in terms of consumption, a situation which is somewhat unique to older adults and seniors.[23–25]

Given the similarity in association between all financial security definitions and allostatic load, and the generally low number of financially insecure older adults within the sample, sample size was a determining factor in the decision to use the most inclusive financial security composite variable for analyses addressing objectives three and four. By this

definition, individuals could hold savings up to $100k and own a house with a mortgage, though all still had to have total household income of less than $50k. Despite this, the most inclusive financial security definition still only included 12.4% of the entire sample (15.5% of females and 9.3% of males), and this was the worst-off 12.4% in terms of financial resources available within the sample. This was a generous concept of 'financial insecurity' compared to other research looking at the relationship between savings and health; one study which found a statistically significant relationship between savings, homeownership and multiple depressive disorder used savings less than $5,000 as the cut-off.[30] While I was limited by the levels within the data provided by the CLSA, the inclusive financial security variable's association with allostatic load was consistent with and similar to the other financial security groups. If anything, the associations found may therefore underestimate the relationships between true financial insecurity, OAS, and allostatic load. Regardless, sample size became the deciding factor in the selection of a financial security composite variable.

6.7. Sensitivity Analyses

The sensitivity analysis comparing the main allostatic load indices with one which accounted for participant's medication use did not reveal any major discrepancies or causes for concern. All trends remained across all models, with coefficients virtually unchanged throughout. My medication-adjusted allostatic load was, however, limited by the lack of specific medication information and number of conditions that were able to be considered. Hypertensive medication was adjusted for by increasing systolic and diastolic blood pressure values, and diabetic medication by increasing the blood percentage of glycated hemoglobin. I was, however, unable to consider those who reported being on medication for heart disease or stroke, for example. This was based on clinical considerations of the wide range of possible medications participants could be on, and the large number of differing effects any of these medications could have on any combination of the biomarkers used for allostatic load. For example, if a participant reported being on a medication for stroke, without knowledge of what the medication was it was impossible to ascertain whether this medication was enacting its effect on total cholesterol versus SBP and DBP, and consequently impossible to determine an appropriate adjustment. The results from this sensitivity analysis are consistent with previous research which has

shown medication to have no major influence on allostatic load,[15,121] but this remains an avenue for future research to improve upon with the appropriate data.[4,23]

The sensitivity analysis comparing the models with and without chronic conditions as a control similarly did not reveal any major differences. No coefficient estimates or odds ratios changed meaningfully between regressions, and all trends remained consistent across all models. When chronic conditions were included, they were associated with increased allostatic load, confirming they were relevant to the relationship at hand.

6.8. Policy Implications

Since the first public pension was instituted in Canada in 1927, discussions surrounding pensions and guaranteed annual income have occupied much Canadian political discourse. Means tested Old Age Security was made universal in 1952, effectively implementing a GAI for everyone aged 70 and older. In 1965, the age of eligibility was decreased to 65, and a year later the portable and contributory Canada Pension Plan/Quebec Pension Plan was implemented. In 1973, Old Age Security became indexed quarterly to protect against inflation; in 1985 the Mulroney government tried to de-index it.[83,84] Public backlash meant that plan never came to fruition, just like the Harper government's decision to raise the age of eligibility of OAS to 67, which was immediately reversed by the newly elected Trudeau government in 2016.[142] Old Age Security as a federally funded, non-contributory pension has had a front-seat in federal politics for years, and the reason is simple. OAS is expensive.

In April, Budget 2022 was announced. The budget, tag lined "A Plan to Grow Our Economy and Make Life More Affordable," assigned $68.2 billion in support for older adults and seniors through Old Age Security in 2022-2023, growing to $87.2 billion by 2026-2027.[143] Increases in OAS funding have been largely attributed to inflation and the number of beneficiaries increasing from what was 4.7 million in 2010, to what will be 9.3 million in 2030.[144] A structural issue for OAS is that increasing longevity of Canadians, particularly amongst higher earners, is extending the duration for which the government must supply payments. Because of this, the costs of OAS are increasing whilst it simultaneously accrues most to those who live the longest i.e., those who might typically be thought of as those who need it the least.[86] Despite this, the 10% increase in OAS

introduced in 2019 was predicted to reduce the number of seniors living below the MBM by 14.6% over five years,[145] and similar reductions may be expected to accompany the increases through to 2027. It was an attempt to address this longevity problem which led then Prime Minister Harper to propose raising the age of eligibility to 67 to reduce the payment period and associated costs of OAS.[142] However, universal changes to OAS fail to consider for whom it matters most. For instance, raising the age of eligibility of OAS does not acknowledge the adverse impact those additional two years could have on the health of financially insecure older adults[146] as they wait for OAS on less generous social assistance. Addressing OAS reform as solely a cost outflow problem fails to consider the larger picture that the results of this study describe: for financially insecure older adults, social spending and income support are health policies too.

Contextualizing Old Age Security as an existing health policy is a policy implication of this study. As Canadian research continues to highlight the feasibility of Guaranteed Annual Income programs within the current federal tax system,[147] and provinces call on the federal government to implement such a program,[148] empirical research on the health benefits of OAS will be increasingly useful in informing decision makers. In addition to this, recommendations and speculations can be made from these results regarding future directions of OAS to ensure its health-improving potential is maximised.

One such recommendation is a targeted expansion of OAS to provide more financially insecure older adults with more sizeable payments. While benefits are already concentrated to those of particularly low-income over 65 through GIS, further increasing the financial resources supplied to financially insecure older adults could improve allostatic load and health well beyond the associations shown in this study. The associations between OAS and allostatic load were not strictly limited to those living in complete poverty, so increasing the lowest income eligible for maximum payments could allow more older adults to experience potentially improved health. Such an increase in funding could be counteracted by tailoring the age or income qualification criteria for OAS receipt, given the diminishing return of OAS on allostatic load seen at higher income levels. While such a change would reduce its universal nature (and potentially be politically unpopular), it could allow Old Age Security to immediately become a more effective income intervention.

Secondly, I speculate that an expanded OAS or GAI framework which incorporates younger populations could hold immense potential as a proactive health intervention. Funding such a program through the existing Canadian federal tax model would be feasible with only minimal changes, such as eliminating the current GST credit and lowering the current basic personal income tax exemption.[147] If similar, or larger, associations with improved health were seen in younger populations from such a program, we could begin to attenuate, or potentially reverse, the considerable income-related health disparities currently seen across the life course in Canada.

6.9. Strengths and Limitations

The results of this study provide further insight into the complex and evolving relationship between income and health. While income and health is widely discussed, little formal literature exists on the specific health impact of a guaranteed annual income, particularly in Canada. This is surprising considering the frequency with which both GAI and public pensions have occupied Canadian political discourse. Allostatic load is also a relatively new health measure in this area of research but is one which, by definition, is particularly relevant to discussions around low income and financial insecurity. As a result, this study represents a timely analytical examination of an important relationship, with a modern approach and applications to Canadian population health and health policy.

The CLSA provided rich data that allowed this study to address a literature gap and expand on the relationship between guaranteed annual income and health. The major strength of using the CLSA is the extensive range of variables it includes, specifically regarding the inclusion of in-depth biomarker and financial information. One challenge to population health research on the social determinants of health and healthy aging is that biomarker information is typically lacking from larger datasets. As a result, self-reported health is commonly relied upon for similar studies. The CLSA, however, contained a wide range of biospecimen and hematology results, including all biomarkers necessary to develop an allostatic load index and observe the biological manifestation of an economic intervention in older adults. This appears to have been a novel observation, particularly for such a large, national survey program.

Another challenge regarding income and health research in older adults and seniors is how personal income may not accurately capture economic consumption. Older adults may report lower income but hold significant non-monetary wealth which would act to buffer against the effects of true low-income. The inclusion of other income-related variables within the CLSA, in addition to income alone, allowed me to develop the financial security composite variables, a flexible variable which identified those with less financial means more accurately. The financial security composite variable also accounted for the possibility of wealthy older adults with decreased income reporting OAS as their highest personal income source. Even though by definition this would be technically true, these were not the individuals I aimed to capture, and ensuring everyone was accurately classified was imperative.

Although not nationally representative, the CLSA allowed me to include a wide range of demographic information, along with sampling and analytical weights, to make the findings as generalizable as possible. Given Old Age Security is a federally administered program, the national scope of this study was important.

By way of statistical analysis, the use of unconditional quantile regression added considerably to this study's findings. The ability to highlight the financially insecure older adults for which OAS had its largest association with improved allostatic load is a major strength of this study and provided a level of real-world context that studying changes in the mean alone may have overlooked. Narrowing the distribution of health outcomes among financially insecure older adults is a positive and important health outcome for a population intervention such as OAS. This is what the unconditional quantile regression determined was happening. Displaying the variability and diminishing returns of OAS will assist in policy recommendations in regard to the future directions of OAS and GAI programs in Canada.

This study has at least four limitations worthy of discussion: (1) the cross-sectional design; (2) sample size; (3) the representativeness of the CLSA; and (4) the lack of sufficient medication data.

The study was of cross-sectional design and as a result, causation was unable to be determined between variables. This design was chosen as there was no follow-up

biomarker data available within the CLSA at the time of analysis. Having longitudinal data would have allowed me to follow individuals before and after they began to receive OAS and compare their changes in health status over time. This would have allowed me to determine if a causal relationship exists between Old Age Security and better health in older Canadian adults. Instead, I was limited to comparing different individuals and groups at a moment of time and drawing associations from these analyses.

CLSA participants tend to be wealthier than the general population.[135] Given the particular focus on older adults of lower income and low overall financial security, this was a considerable limitation. Power and sample size became a factor during analyses, particularly in the selection of a financial security composite variable, which was selected based on sample size and financial criteria, as opposed to strictly financial criteria alone. The more inclusive criteria used means it is possible the true associations of financial security and allostatic load are underestimated in this analysis, but the use of this composite variable ensured that the results obtained were robust.

Power was also a limitation for the unconditional quantile regressions. While the observed trends all followed similar patterns, several coefficients for financially insecure females were not statistically significant, and confidence intervals were large for both financially insecure male distributions too. The financially insecure group and OAS as highest personal income source were both small groups relative to the overall sample size, and these groups were further dissected into quantiles based on their allostatic load score to undergo this analysis. As a result, sample size was small, and power was lost. However, the use of unconditional quantile regression in this manner is a relatively new approach to this area of health research, so this analysis should serve as a useful baseline guide for future research on modelling health outcomes beyond the mean.

The CLSA is not nationally representative of Canada. Recruitment requires active selection and participation from individuals who are largely urban, and New Brunswick, Prince Edward Island, and Saskatchewan are all not included in the comprehensive cohort used for this study. While inflation and analytical weights were used as directed,[110] such weights only serve to make the sample more representative of the sampling frame, which due to the requirements of the DSCs, was mostly urban Canadians. This represents a

mechanism through which the sample may overrepresent well-off Canadians. Given OAS's federal and universal nature, the lack of a nationally representative sample is a limitation that means the results of this study are only generalizable to the people represented within the CLSA.[66]

Finally, a lack of data meant that medication use was unable to be completely adjusted for. It is possible that certain values of individual biomarkers, therefore, remained inflated or deflated due to medication, and in using only the absolute value, high-risk classifications could have been overlooked. While a sensitivity analysis was conducted to address this, only three biomarkers were adjusted due to data limitations and clinical considerations (SBP, DBP and glycated hemoglobin). More specific medication information would have meant a more complete adjustment could have been made on the allostatic load index.

6.10. Implications for Future Research

This study established an association between desirable health outcomes and receiving GAI among financially insecure older adults, a field which remains underdeveloped in Canada today. It therefore presents a relatively novel approach to understanding the complex and ever-evolving relationship between income and health. By assessing how allostatic load improves with OAS receipt, a meaningful and ongoing economic intervention, I have shown how the income-health relationship may be malleable. Strong, proactive policies targeting those who need help the most may hold the ability to improve health in some of the most vulnerable Canadians. As a result, the groundwork has been laid for future research looking to establish further evidence for the relationships between GAI and objective health measures in Canada and around the world.

Future research in this area should incorporate cohorts which are more focused on, or representative of, financially insecure populations. Health is known to be strongly patterned by wealth and income, so it proved difficult to investigate the role of financial insecurity in a sample which was wealthier than the general population. Future research in this area should utilize cohorts more representative of their target population, so any results seen will be more generalizable to the populations they aim to help.

Future research should also capitalize on longitudinal data, if available, in order to draw causal inferences from any relationships found. In Canada, this could involve using follow-up biomarker data from the CLSA, which was unavailable to this study when it began. Causal evidence of objective health benefits from Old Age Security, or GAI in general, would mark a significant contribution to the literature and would further add to the claim that, with proactive intervention, the income and health relationship may indeed be malleable.

Any study investigating objective health as measured through allostatic load may look to explore the differences that are seen when sex-specific cut-offs are used, both clinically and empirically, and any gendered aspect to these results due to differences in labour market participation, for example. Allostatic load is known to differ between males and females, so it may have important differences in its associations with income-related variables too. Access to detailed medication data would also further enhance the validity of allostatic load by reflecting health conditions for which participants are being treated. This is particularly relevant for older adult and senior populations, where medication use is more common and accounting for it is important for health and policy considerations.

Finally, an additional consideration for older populations could involve assessing a frailty index alongside allostatic load, to assess any differences between the two relevant health measures. Lab-based frailty indices[105–107] contain several of the same variables as allostatic load, so while subsets of these variables are attempting to capture similar concepts (e.g., Systolic and Diastolic Blood Pressure), others are fundamentally different (e.g., gait speed). Such a comparison, therefore, would provide an interesting commentary on two increasingly relevant measures of health, particularly for older adults and seniors, and how they are patterned by various income-related variables.

6.11. Conclusion

This study represents a useful finding for income and health research and has shown how GAI may improve the health of some of Canada's most vulnerable older adults. I have shown allostatic load is patterned by income-related variables and financial security, and how it is associated with improvements in financially insecure older adults when they receive OAS as highest personal income source. This association is greatest for those

who have the worst allostatic load, narrowing the population distribution of allostatic load and potentially reducing the susceptibility of vulnerable older Canadians to many adverse health outcomes. This constitutes valuable evidence for the use of a GAI as a health intervention that has the potential to narrow income-related health inequalities amongst older adults, and potentially amongst the many other vulnerable groups whom we insist survive until 65 before they qualify for more generous public payments.

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APPENDIX 1 FULL ORDERED LOGISTIC REGRESSION OUTPUTS

1. Total Personal Income and Empirical and Clinical Allostatic Load associations (Objective Two)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Total Personal Income				
<$20k	1.281*	1.442*	1.321*	1.295*
	(1.062 - 1.544)	(1.206 - 1.725)	(1.153 - 1.514)	(1.128 - 1.487)
$20k-$50k	1.110	1.121*	1.181*	1.158*
	(0.999 - 1.232)	(1.007 - 1.249)	(1.056 - 1.320)	(1.034 - 1.296)
$50k-$100k	Ref	Ref	Ref	Ref
$100k-$150k	0.973	0.951	1.094	1.071
	(0.843 - 1.123)	(0.822 - 1.100)	(0.878 - 1.363)	(0.840 - 1.365)
$150k+	0.861	0.895	0.937	0.956
	(0.724 - 1.024)	(0.743 - 1.077)	(0.683 - 1.284)	(0.714 - 1.281)
Missing	1.194	1.03	1.068	0.958
	(0.948 - 1.503)	(0.813 - 1.305)	(0.888 - 1.285)	(0.795 - 1.154)
Age	1.220*	1.189*	1.018*	1.017*
	(1.020 - 1.459)	(0.988 - 1.431)	(1.009 - 1.027)	(1.008 - 1.027)
Age-Squared	0.998	0.999	-	-
	(0.997 - 1.000)	(0.997 - 1.000)	-	-
Marital Status				
Single	1.253*	1.165*	1.299*	1.284*
	(1.120 - 1.401)	(1.037 - 1.310)	(1.189 - 1.419)	(1.173 - 1.407)
Married/Living with Partner	Ref	Ref	Ref	Ref
Visible Minority Status				
Visible Minority	1.051	0.936	1.153	1.189
	(0.857 - 1.290)	(0.746 - 1.175)	(0.912 - 1.456)	(0.930 - 1.520)
Non-Visible Minority	Ref	Ref	Ref	Ref
Retirement Status				
Completely Retired	0.862*	0.865*	1.032	1.021
	(0.769 - 0.966)	(0.769 - 0.973)	(0.923 - 1.154)	(0.911 - 1.143)
Partially Retired	0.91	0.919	0.985	1.112
	(0.798 - 1.038)	(0.803 - 1.052)	(0.857 - 1.133)	(0.964 - 1.283)
Not Retired	Ref	Ref	Ref	Ref
Province				
British Columbia	Ref	Ref	Ref	Ref

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Alberta	0.859 (0.732 - 1.010)	0.92 (0.778 - 1.088)	0.961 (0.820 - 1.127)	0.946 (0.803 - 1.115)
Manitoba	1.433* (1.225 - 1.675)	1.632* (1.384 - 1.924)	1.522* (1.301 - 1.780)	1.381* (1.179 - 1.617)
Ontario	1.254* (1.099 - 1.430)	1.293* (1.134 - 1.474)	1.438* (1.262 - 1.639)	1.369* (1.199 - 1.563)
Quebec	0.888 (0.772 - 1.021)	0.94 (0.819 - 1.078)	1.216* (1.062 - 1.392)	1.163* (1.012 - 1.336)
Nova Scotia	0.995 (0.843 - 1.174)	0.955 (0.804 - 1.133)	1.178* (0.998 - 1.391)	1.196* (1.015 - 1.409)
Newfoundland	1.201 (0.996 - 1.447)	1.251* (1.043 - 1.501)	1.210* (1.008 - 1.453)	1.193* (0.989 - 1.439)
Education				
Non-High School Graduate	1.904* (1.534 - 2.365)	1.755* (1.428 - 2.156)	1.626* (1.322 - 2.000)	1.695* (1.381 - 2.081)
High School Graduate	1.501* (1.302 - 1.730)	1.386* (1.195 - 1.607)	1.379* (1.193 - 1.594)	1.451* (1.251 - 1.684)
Diploma/Certificate	1.532* (1.360 - 1.726)	1.333* (1.179 - 1.507)	1.253* (1.105 - 1.422)	1.304* (1.145 - 1.484)
Bachelor's Degree	1.055 (0.936 - 1.190)	0.975 (0.862 - 1.104)	0.989 (0.864 - 1.132)	1.018 (0.888 - 1.166)
Higher than Bachelor's degree	Ref	Ref	Ref	Ref
Chronic Conditions				
None	Ref	Ref	Ref	Ref
At least one	1.591* (1.354 - 1.870)	1.630* (1.380 - 1.926)	1.575* (1.280 - 1.937)	1.552* (1.266 - 1.901)
Smoking Status				
Never Smoked	Ref	Ref	Ref	Ref
Former Smoker	1.131* (1.025 - 1.249)	1.170* (1.055 - 1.297)	1.079 (0.983 - 1.185)	1.123* (1.023 - 1.233)
Occasional smoker	1.363 (0.937 - 1.982)	1.466* (1.050 - 2.046)	1.182 (0.800 - 1.747)	1.14 (0.805 - 1.616)
Daily Smoker	2.067* (1.703 - 2.509)	1.853* (1.515 - 2.265)	1.719* (1.436 - 2.058)	1.641* (1.357 - 1.984)
Alcohol Consumption				
Regular Drinker	Ref	Ref	Ref	Ref
Occasional Drinker	1.625* (1.378 - 1.916)	1.707* (1.426 - 2.044)	1.745* (1.541 - 1.976)	1.641* (1.451 - 1.855)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Do not drink	1.415* (1.235 - 1.622)	1.432* (1.249 - 1.642)	1.574* (1.375 - 1.801)	1.482* (1.292 - 1.701)

2. Total Household Income and Empirical and Clinical Allostatic Load associations (Objective Two)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Total Household Income				
<$20k	1.549* (1.167 - 2.055)	1.635* (1.215 - 2.200)	1.378* (1.083 - 1.755)	1.330* (1.044 - 1.694)
$20k-$50k	1.263* (1.086 - 1.468)	1.174* (1.008 - 1.368)	1.284* (1.105 - 1.493)	1.292* (1.103 - 1.512)
$50k-$100k	1.092 (0.972 - 1.227)	1.004 (0.890 - 1.132)	1.09 (0.958 - 1.241)	1.181* (1.032 - 1.351)
$100k-$150k	Ref	Ref	Ref	Ref
$150k+	1.004 (0.872 - 1.155)	0.943 (0.818 - 1.087)	0.978 (0.828 - 1.155)	1.053 (0.890 - 1.245)
Missing	1.391* (1.112 - 1.739)	1.076 (0.853 - 1.357)	1.036 (0.862 - 1.246)	0.92 (0.762 - 1.111)
Age	1.217* (1.018 - 1.455)	1.195* (0.993 - 1.438)	1.016* (1.007 - 1.025)	1.016* (1.007 - 1.025)
Age-Squared	0.999 (0.997 - 1.000)	0.999 (0.997 - 1.000)	- -	- -
Marital Status				
Single	1.161* (1.032 - 1.307)	1.093 (0.966 - 1.237)	1.164* (1.054 - 1.285)	1.179* (1.063 - 1.306)
Married/Living with Partner	Ref	Ref	Ref	Ref
Visible Minority Status				
Visible Minority	1.039 (0.847 - 1.275)	0.932 (0.742 - 1.171)	1.147 (0.908 - 1.449)	1.185 (0.929 - 1.513)
Non-Visible Minority	Ref	Ref	Ref	Ref
Retirement Status				
Completely Retired	0.871* (0.778 - 0.976)	0.885* (0.787 - 0.995)	1.05 (0.940 - 1.173)	1.036 (0.925 - 1.160)
Partially Retired	0.925 (0.812 - 1.055)	0.938 (0.820 - 1.074)	0.991 (0.862 - 1.139)	1.116 (0.967 - 1.288)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Not Retired	Ref	Ref	Ref	Ref
Province				
British Columbia	Ref	Ref	Ref	Ref
Alberta	0.844*	0.91	0.966	0.959
	(0.718 - 0.991)	(0.769 - 1.077)	(0.824 - 1.132)	(0.814 - 1.130)
Manitoba	1.436*	1.639*	1.522*	1.379*
	(1.229 - 1.679)	(1.390 - 1.932)	(1.301 - 1.781)	(1.177 - 1.615)
Ontario	1.250*	1.288*	1.444*	1.374*
	(1.095 - 1.427)	(1.129 - 1.470)	(1.268 - 1.646)	(1.203 - 1.568)
Quebec	0.883	0.943	1.207*	1.157*
	(0.767 - 1.016)	(0.822 - 1.082)	(1.054 - 1.382)	(1.006 - 1.330)
Nova Scotia	0.988	0.946	1.178	1.193*
	(0.837 - 1.165)	(0.797 - 1.124)	(0.998 - 1.390)	(1.013 - 1.405)
Newfoundland	1.192	1.237*	1.196	1.180
	(0.988 - 1.437)	(1.031 - 1.484)	(0.996 - 1.436)	(0.978 - 1.422)
Education				
Non-High School Graduate	1.881*	1.776*	1.635*	1.750*
	(1.512 - 2.339)	(1.443 - 2.185)	(1.327 - 2.015)	(1.423 - 2.152)
High School Graduate	1.509*	1.413*	1.394*	1.476*
	(1.309 - 1.740)	(1.218 - 1.639)	(1.207 - 1.611)	(1.272 - 1.713)
Diploma/Certificate	1.538*	1.350*	1.266*	1.324*
	(1.366 - 1.732)	(1.194 - 1.527)	(1.116 - 1.435)	(1.163 - 1.508)
Bachelor's Degree	1.062	0.984	0.993	1.027
	(0.942 - 1.197)	(0.869 - 1.113)	(0.868 - 1.136)	(0.896 - 1.177)
Higher than Bachelors degree	Ref	Ref	Ref	Ref
Chronic Conditions				
None	Ref	Ref	Ref	Ref
At least one	1.601*	1.646*	1.586*	1.559*
	(1.364 - 1.879)	(1.393 - 1.944)	(1.289 - 1.952)	(1.271 - 1.914)
Smoking Status				
Never Smoked	Ref	Ref	Ref	Ref
Former Smoker	1.137*	1.173*	1.077	1.121*
	(1.030 - 1.255)	(1.058 - 1.301)	(0.981 - 1.183)	(1.021 - 1.231)
Occasional smoker	1.387*	1.497*	1.192	1.146
	(0.956 - 2.012)	(1.075 - 2.084)	(0.808 - 1.758)	(0.810 - 1.621)
Daily Smoker	2.088*	1.885*	1.712*	1.643*
	(1.720 - 2.535)	(1.543 - 2.303)	(1.430 - 2.049)	(1.359 - 1.987)
Alcohol Consumption				

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Regular Drinker	Ref	Ref	Ref	Ref
Occasional Drinker	1.623*	1.708*	1.723*	1.627*
	(1.376 - 1.915)	(1.425 - 2.046)	(1.522 - 1.951)	(1.439 - 1.840)
Do not drink	1.406*	1.430*	1.573*	1.499*
	(1.226 - 1.612)	(1.246 - 1.641)	(1.375 - 1.800)	(1.308 - 1.718)

3. Homeownership Status and Empirical and Clinical Allostatic Load associations (Objective Two)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Homeownership				
Does not Own Home	1.697*	1.498*	1.582*	1.614*
	(1.468 - 1.963)	(1.286 - 1.745)	(1.369 - 1.828)	(1.404 - 1.856)
Owns Home with Mortgage	1.388*	1.232*	1.287*	1.369*
	(1.255 - 1.535)	(1.110 - 1.368)	(1.161 - 1.427)	(1.234 - 1.518)
Owns Home Outright	Ref	Ref	Ref	Ref
Missing	1.418	1.493	0.744	0.852
	(0.809 - 2.485)	(0.873 - 2.553)	(0.441 - 1.254)	(0.450 - 1.610)
Age	1.250*	1.223*	1.020*	1.020*
	(1.046 - 1.493)	(1.017 - 1.472)	(1.011 - 1.029)	(1.011 - 1.029)
Age-Squared	0.998	0.999	-	-
	(0.997 - 1.000)	(0.997 - 1.000)	-	-
Marital Status				
Single	1.153*	1.104	1.146*	1.136*
	(1.026 - 1.295)	(0.978 - 1.247)	(1.044 - 1.258)	(1.032 - 1.250)
Married/Living with Partner	Ref	Ref	Ref	Ref
Visible Minority Status				
Visible Minority	1.038	0.944	1.129	1.153
	(0.848 - 1.272)	(0.752 - 1.184)	(0.893 - 1.427)	(0.901 - 1.475)
Non-Visible Minority	Ref	Ref	Ref	Ref
Retirement Status				
Completely Retired	0.967	0.952	1.127*	1.120*
	(0.863 - 1.082)	(0.848 - 1.068)	(1.007 - 1.260)	(0.999 - 1.254)
Partially Retired	0.982	0.984	1.048	1.188**
	(0.862 - 1.118)	(0.861 - 1.125)	(0.911 - 1.205)	(1.028 - 1.371)
Not Retired	Ref	Ref	Ref	Ref

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Province				
British Columbia	Ref	Ref	Ref	Ref
Alberta	0.867 (0.740 - 1.017)	0.918 (0.776 - 1.086)	0.99 (0.846 - 1.160)	0.977 (0.830 - 1.150)
Manitoba	1.452* (1.242 - 1.697)	1.649* (1.399 - 1.944)	1.534* (1.312 - 1.795)	1.403* (1.198 - 1.643)
Ontario	1.254* (1.100 - 1.430)	1.288* (1.129 - 1.469)	1.433* (1.258 - 1.633)	1.374* (1.204 - 1.568)
Quebec	0.875 (0.760 - 1.006)	0.94 (0.819 - 1.078)	1.187* (1.037 - 1.360)	1.139 (0.991 - 1.308)
Nova Scotia	0.969 (0.821 - 1.143)	0.929 (0.781 - 1.104)	1.158 (0.981 - 1.368)	1.176 (0.998 - 1.386)
Newfoundland	1.207* (1.002 - 1.454)	1.251* (1.044 - 1.500)	1.186 (0.987 - 1.424)	1.173 (0.972 - 1.415)
Education				
Non-High School Graduate	1.945* (1.568 - 2.412)	1.851* (1.512 - 2.268)	1.691* (1.378 - 2.074)	1.754* (1.436 - 2.144)
High School Graduate	1.522* (1.324 - 1.749)	1.432* (1.240 - 1.653)	1.437* (1.249 - 1.653)	1.494* (1.293 - 1.725)
Diploma/Certificate	1.575* (1.404 - 1.767)	1.382* (1.226 - 1.558)	1.306* (1.158 - 1.475)	1.345* (1.187 - 1.524)
Bachelor's Degree	1.081 (0.960 - 1.217)	1 (0.885 - 1.130)	1.01 (0.884 - 1.153)	1.036 (0.905 - 1.186)
Higher than bachelor's degree	Ref	Ref	Ref	Ref
Chronic Conditions				
None	Ref	Ref	Ref	Ref
At least one	1.570* (1.336 - 1.844)	1.627* (1.376 - 1.923)	1.574* (1.276 - 1.941)	1.538* (1.250 - 1.891)
Smoking Status				
Never Smoked				
Former Smoker	1.114* (1.009 - 1.230)	1.161* (1.047 - 1.287)	1.057 (0.963 - 1.160)	1.096* (0.998 - 1.204)
Occasional smoker	1.356 (0.933 - 1.971)	1.483* (1.063 - 2.070)	1.131 (0.757 - 1.691)	1.086 (0.763 - 1.547)
Daily Smoker	1.993* (1.637 - 2.425)	1.840* (1.505 - 2.249)	1.634* (1.362 - 1.960)	1.548* (1.278 - 1.874)
Alcohol Consumption				
Regular Drinker	Ref	Ref	Ref	Ref

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Occasional Drinker	1.614*	1.723*	1.737*	1.633*
	(1.372 - 1.898)	(1.439 - 2.062)	(1.534 - 1.967)	(1.445 - 1.845)
Do not drink	1.409*	1.438*	1.563*	1.470*
	(1.230 - 1.613)	(1.255 - 1.648)	(1.368 - 1.786)	(1.283 - 1.684)

4. Total Savings and Empirical and Clinical Allostatic Load associations (Objective Two)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Total Savings				
<$50k	1.473*	1.330*	1.625*	1.515*
	(1.290 - 1.682)	(1.156 - 1.532)	(1.435 - 1.842)	(1.333 - 1.723)
$50k-$100k	1.254*	1.153*	1.118	1.170*
	(1.089 - 1.445)	(1.001 - 1.330)	(0.975 - 1.281)	(1.022 - 1.339)
$100k-$1m	Ref	Ref	Ref	Ref
$1m+	0.91	0.880*	0.89	0.870*
	(0.798 - 1.039)	(0.767 - 1.011)	(0.757 - 1.045)	(0.743 - 1.018)
Missing	1.151	1.220*	1.068	1.01
	(0.998 - 1.327)	(1.053 - 1.413)	(0.945 - 1.207)	(0.891 - 1.144)
Age	1.257*	1.226*	1.018*	1.017*
	(1.052 - 1.503)	(1.019 - 1.476)	(1.009 - 1.027)	(1.008 - 1.026)
Age-Squared	0.998	0.998	-	-
	(0.997 - 1.000)	(0.997 - 1.000)	-	-
Marital Status				
Single	1.215*	1.148*	1.194*	1.192*
	(1.086 - 1.360)	(1.020 - 1.292)	(1.093 - 1.304)	(1.088 - 1.306)
Married/Living with Partner	Ref	Ref	Ref	Ref
Visible Minority Status				
Visible Minority	1.01	0.918	1.145	1.177
	(0.822 - 1.240)	(0.730 - 1.154)	(0.908 - 1.444)	(0.921 - 1.505)
Non-Visible Minority	Ref	Ref	Ref	Ref
Retirement Status				
Completely Retired	0.907	0.914	1.098*	1.079
	(0.812 - 1.014)	(0.817 - 1.024)	(0.983 - 1.227)	(0.964 - 1.208)
Partially Retired	0.946	0.958	1.031	1.158*
	(0.831 - 1.077)	(0.839 - 1.095)	(0.897 - 1.186)	(1.003 - 1.336)
Not Retired	Ref	Ref	Ref	Ref
Province				
British Columbia	Ref	Ref	Ref	Ref
Alberta	0.858	0.921	0.979	0.955
	(0.732 - 1.006)	(0.779 - 1.089)	(0.835 - 1.148)	(0.811 - 1.123)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Manitoba	1.426* (1.219 - 1.669)	1.624* (1.376 - 1.917)	1.524* (1.303 - 1.783)	1.377* (1.176 - 1.613)
Ontario	1.226* (1.075 - 1.398)	1.263* (1.106 - 1.441)	1.429* (1.255 - 1.627)	1.358* (1.190 - 1.550)
Quebec	0.831 (0.720 - 0.958)	0.908 (0.789 - 1.044)	1.122 (0.979 - 1.287)	1.077 (0.935 - 1.240)
Nova Scotia	0.956 (0.809 - 1.128)	0.918 (0.772 - 1.091)	1.153 (0.977 - 1.361)	1.169 (0.992 - 1.377)
Newfoundland	1.133 (0.940 - 1.364)	1.180 (0.984 - 1.416)	1.13 (0.940 - 1.358)	1.118 (0.925 - 1.352)
Education				
Non-High School Graduate	1.861* (1.501 - 2.308)	1.765* (1.439 - 2.166)	1.558* (1.270 - 1.911)	1.648* (1.345 - 2.019)
High School Graduate	1.484* (1.289 - 1.708)	1.386* (1.197 - 1.604)	1.380* (1.197 - 1.591)	1.446* (1.249 - 1.674)
Diploma/Certificate	1.528* (1.359 - 1.718)	1.333* (1.180 - 1.506)	1.254* (1.109 - 1.419)	1.304* (1.149 - 1.481)
Bachelor's Degree	1.063 (0.944 - 1.198)	0.983 (0.870 - 1.111)	0.991 (0.866 - 1.133)	1.018 (0.889 - 1.167)
Higher than Bachelor's degree	Ref	Ref	Ref	Ref
Chronic Conditions				
None	Ref	Ref	Ref	Ref
At least one	1.586* (1.350 - 1.864)	1.645* (1.392 - 1.943)	1.560* (1.267 - 1.920)	1.539* (1.256 - 1.888)
Smoking Status				
Never Smoked	Ref	Ref	Ref	Ref
Former Smoker	1.124* (1.018 - 1.240)	1.163* (1.048 - 1.290)	1.073 (0.978 - 1.178)	1.116* (1.016 - 1.225)
Occasional smoker	1.351 (0.933 - 1.954)	1.473* (1.062 - 2.044)	1.139 (0.762 - 1.702)	1.102 (0.773 - 1.570)
Daily Smoker	2.005* (1.652 - 2.434)	1.847* (1.511 - 2.257)	1.655* (1.380 - 1.984)	1.590* (1.315 - 1.923)
Alcohol Consumption				
Regular Drinker	Ref	Ref	Ref	Ref
Occasional Drinker	1.607* (1.363 - 1.895)	1.702* (1.421 - 2.038)	1.695* (1.498 - 1.918)	1.597* (1.413 - 1.804)
Do not drink	1.407* (1.228 - 1.611)	1.439* (1.255 - 1.649)	1.533* (1.342 - 1.751)	1.453* (1.268 - 1.665)

5. Financial Security (Inclusive) and Empirical and Clinical Allostatic Load associations (Objective Two)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Financial Security				
Financially Insecure	1.389*	1.512*	1.483*	1.471*
	(1.181 - 1.634)	(1.279 - 1.787)	(1.301 - 1.691)	(1.287 - 1.681)
Financially Secure	Ref	Ref	Ref	Ref
Age	1.233*	1.211*	1.018*	1.017*
	(1.032 - 1.473)	(1.007 - 1.458)	(1.009 - 1.027)	(1.008 - 1.026)
Age-Squared	0.998	0.999	-	-
	(0.997 - 1.000)	(0.997 - 1.000)	-	-
Marital Status				
Single	1.199*	1.107	1.166*	1.161*
	(1.068 - 1.347)	(0.981 - 1.249)	(1.064 - 1.278)	(1.057 - 1.276)
Married/Living with Partner	Ref	Ref	Ref	Ref
Visible Minority Status				
Visible Minority	1.044	0.928	1.128	1.164
	(0.851 - 1.281)	(0.738 - 1.165)	(0.893 - 1.424)	(0.909 - 1.490)
Non-Visible Minority	Ref	Ref	Ref	Ref
Retirement Status				
Completely Retired	0.901	0.909	1.079	1.061
	(0.806 - 1.006)	(0.811 - 1.017)	(0.966 - 1.206)	(0.948 - 1.187)
Partially Retired	0.943	0.956	1.016	1.143
	(0.828 - 1.073)	(0.837 - 1.093)	(0.884 - 1.168)	(0.991 - 1.319)
Not Retired	Ref	Ref	Ref	Ref
Province				
British Columbia	Ref	Ref	Ref	Ref
Alberta	0.839*	0.901	0.963	0.943
	(0.716 - 0.984)	(0.762 - 1.066)	(0.821 - 1.128)	(0.802 - 1.110)
Manitoba	1.446*	1.648*	1.526*	1.386*
	(1.237 - 1.691)	(1.398 - 1.942)	(1.305 - 1.785)	(1.184 - 1.622)
Ontario	1.236*	1.278*	1.430*	1.366*
	(1.084 - 1.410)	(1.120 - 1.458)	(1.256 - 1.628)	(1.197 - 1.559)
Quebec	0.879	0.934	1.183*	1.136*
	(0.764 - 1.012)	(0.814 - 1.072)	(1.032 - 1.355)	(0.988 - 1.306)
Nova Scotia	0.98	0.937	1.171	1.184*
	(0.831 - 1.156)	(0.789 - 1.113)	(0.992 - 1.382)	(1.005 - 1.394)
Newfoundland	1.182	1.228*	1.170	1.157
	(0.980 - 1.424)	(1.024 - 1.472)	(0.975 - 1.404)	(0.959 - 1.396)
Education				
Non-High School Graduate	1.952*	1.812*	1.649*	1.718*
	(1.576 - 2.418)	(1.480 - 2.220)	(1.345 - 2.022)	(1.406 - 2.100)
High School Graduate	1.560*	1.439*	1.429*	1.491*

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
	(1.357 - 1.793)	(1.246 - 1.662)	(1.242 - 1.645)	(1.290 - 1.723)
Diploma/Certificate	1.580*	1.369*	1.293*	1.335*
	(1.408 - 1.774)	(1.214 - 1.544)	(1.145 - 1.460)	(1.177 - 1.514)
Bachelor's Degree	1.08	0.997	1.009	1.033
	(0.959 - 1.216)	(0.882 - 1.127)	(0.883 - 1.152)	(0.902 - 1.183)
Higher than Bachelor's Degree	Ref	Ref	Ref	Ref
Chronic Conditions				
None	Ref	Ref	Ref	Ref
At least one	1.601*	1.641*	1.573*	1.544*
	(1.363 - 1.879)	(1.389 - 1.939)	(1.278 - 1.938)	(1.259 - 1.895)
Smoking Status				
Never Smoked	Ref	Ref	Ref	Ref
Former Smoker	1.126*	1.166*	1.069	1.112*
	(1.020 - 1.242)	(1.052 - 1.293)	(0.974 - 1.174)	(1.013 - 1.221)
Occasional smoker	1.371*	1.495*	1.165	1.119
	(0.945 - 1.990)	(1.074 - 2.081)	(0.789 - 1.721)	(0.792 - 1.580)
Daily Smoker	2.064*	1.864*	1.670*	1.587*
	(1.701 - 2.504)	(1.526 - 2.276)	(1.396 - 1.999)	(1.313 - 1.918)
Alcohol Consumption				
Regular Drinker	Ref	Ref	Ref	Ref
Occasional Drinker	1.624*	1.703*	1.718*	1.616*
	(1.378 - 1.914)	(1.422 - 2.041)	(1.518 - 1.945)	(1.430 - 1.826)
Do not drink	1.420*	1.433*	1.555*	1.466*
	(1.239 - 1.627)	(1.250 - 1.644)	(1.361 - 1.777)	(1.279 - 1.680)

6. Financial Security, Allostatic Load and Old Age Security (Objective Three)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Financial security				
Financially Insecure	1.436*	1.569*	1.571*	1.544*
	(1.212 - 1.701)	(1.316 - 1.871)	(1.365 - 1.807)	(1.335 - 1.785)
Financially Secure	Ref	Ref	Ref	Ref
Highest Personal Income Source				
OAS	1.919*	2.120*	1.162	1.175

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
	(1.314 - 2.802)	(1.476 - 3.045)	(0.930 - 1.452)	(0.943 - 1.464)
Other	Ref	Ref	Ref	Ref
Interaction Term				
Financially Insecure*OAS	0.441*	0.398*	0.637*	0.677*
	(0.246 - 0.790)	(0.227 - 0.696)	(0.450 - 0.901)	(0.483 - 0.949)
Age	1.231*	1.209*	1.018*	1.017*
	(1.030 - 1.471)	(1.004 - 1.454)	(1.009 - 1.027)	(1.008 - 1.026)
Age-Squared	0.998	0.999		
	(0.997 - 1.000)	(0.997 - 1.000)		
Marital Status				
Single	1.195*	1.104	1.168*	1.164*
	(1.064 - 1.343)	(0.978 - 1.246)	(1.065 - 1.280)	(1.059 - 1.279)
Married/Living with Partner	Ref	Ref	Ref	Ref
Visible Minority Status				
Visible Minority	1.043	0.929	1.124	1.163
	(0.851 - 1.280)	(0.739 - 1.167)	(0.890 - 1.420)	(0.908 - 1.490)
Non-Visible Minority	Ref	Ref	Ref	Ref
Retirement Status				
Completely Retired	0.898	0.906	1.082	1.062
	(0.804 - 1.003)	(0.809 - 1.014)	(0.969 - 1.209)	(0.949 - 1.188)
Partially Retired	0.942	0.955	1.019	1.145*
	(0.828 - 1.073)	(0.836 - 1.091)	(0.886 - 1.172)	(0.992 - 1.321)
Not Retired	Ref	Ref	Ref	Ref
Province				
British Columbia	Ref	Ref	Ref	Ref
Alberta	0.837*	0.9	0.963	0.944
	(0.714 - 0.982)	(0.761 - 1.065)	(0.821 - 1.128)	(0.802 - 1.110)
Manitoba	1.440*	1.639*	1.522*	1.382*
	(1.232 - 1.684)	(1.390 - 1.932)	(1.301 - 1.780)	(1.180 - 1.618)
Ontario	1.240*	1.284*	1.428*	1.366*
	(1.088 - 1.415)	(1.125 - 1.465)	(1.254 - 1.626)	(1.197 - 1.558)
Quebec	0.875	0.929	1.179*	1.133*
	(0.760 - 1.007)	(0.810 - 1.067)	(1.029 - 1.352)	(0.985 - 1.303)
Nova Scotia	0.979	0.936	1.169	1.179
	(0.830 - 1.155)	(0.788 - 1.112)	(0.990 - 1.379)	(1.000 - 1.389)
Newfoundland	1.176	1.222*	1.168	1.155
	(0.976 - 1.419)	(1.019 - 1.465)	(0.973 - 1.403)	(0.957 - 1.394)
Education				
Non-High School Graduate	1.917*	1.775*	1.657*	1.718*
	(1.548 - 2.374)	(1.449 - 2.175)	(1.349 - 2.036)	(1.403 - 2.104)

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
High School Graduate	1.553* (1.351 - 1.785)	1.430* (1.237 - 1.652)	1.418* (1.232 - 1.633)	1.478* (1.278 - 1.708)
Diploma/Certificate	1.567* (1.395 - 1.759)	1.356* (1.202 - 1.529)	1.285* (1.138 - 1.452)	1.327* (1.170 - 1.505)
Bachelor's Degree	1.078 (0.957 - 1.213)	0.994 (0.880 - 1.123)	1.006 (0.881 - 1.150)	1.03 (0.900 - 1.180)
Higher than Bachelor's Degree	Ref	Ref	Ref	Ref
Chronic Conditions				
None	Ref	Ref	Ref	Ref
At least one	1.600* (1.362 - 1.879)	1.639* (1.387 - 1.937)	1.576* (1.280 - 1.941)	1.547* (1.261 - 1.897)
Smoking Status				
Never Smoked	Ref	Ref	Ref	Ref
Former Smoker	1.125* (1.019 - 1.242)	1.167* (1.052 - 1.294)	1.068 (0.973 - 1.173)	1.111* (1.012 - 1.220)
Occasional smoker	1.374 (0.948 - 1.992)	1.503* (1.081 - 2.089)	1.167 (0.790 - 1.725)	1.119 (0.792 - 1.579)
Daily Smoker	2.044* (1.685 - 2.481)	1.841* (1.507 - 2.249)	1.668* (1.393 - 1.996)	1.584* (1.310 - 1.914)
Alcohol Consumption				
Regular Drinker	Ref	Ref	Ref	Ref
Occasional Drinker	1.617* (1.373 - 1.906)	1.695* (1.415 - 2.031)	1.711* (1.512 - 1.937)	1.611* (1.426 - 1.821)
Do not drink	1.419* (1.238 - 1.626)	1.432* (1.249 - 1.643)	1.554* (1.360 - 1.777)	1.463* (1.277 - 1.677)

7. Sensitivity Analysis Output: Financial Security, Allostatic Load and Old Age Security (Objective Three) with Chronic Conditions Removed

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Financial security				
Financially Insecure	1.445* (1.220 - 1.710)	1.585* (1.329 - 1.889)	1.573* (1.367 - 1.810)	1.547* (1.338 - 1.788)
Financially Secure	Ref	Ref	Ref	Ref
Highest Personal Income Source				
OAS	1.926*	2.130*	1.150	1.165

	Male		Female	
	Empirical AL	**Clinical AL**	**Empirical AL**	**Clinical AL**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
	(1.316 – 2.821)	(1.482 - 3.060)	(0.921 - 1.436)	(0.936 - 1.450)
Other	Ref	Ref	Ref	Ref
Interaction Term				
Financially Insecure*OAS	0.439*	0.396*	0.641*	0.680*
	(0.244 – 0.788)	(0.226 – 0.693)	(0.454 – 0.906)	(0.486 – 0.952)